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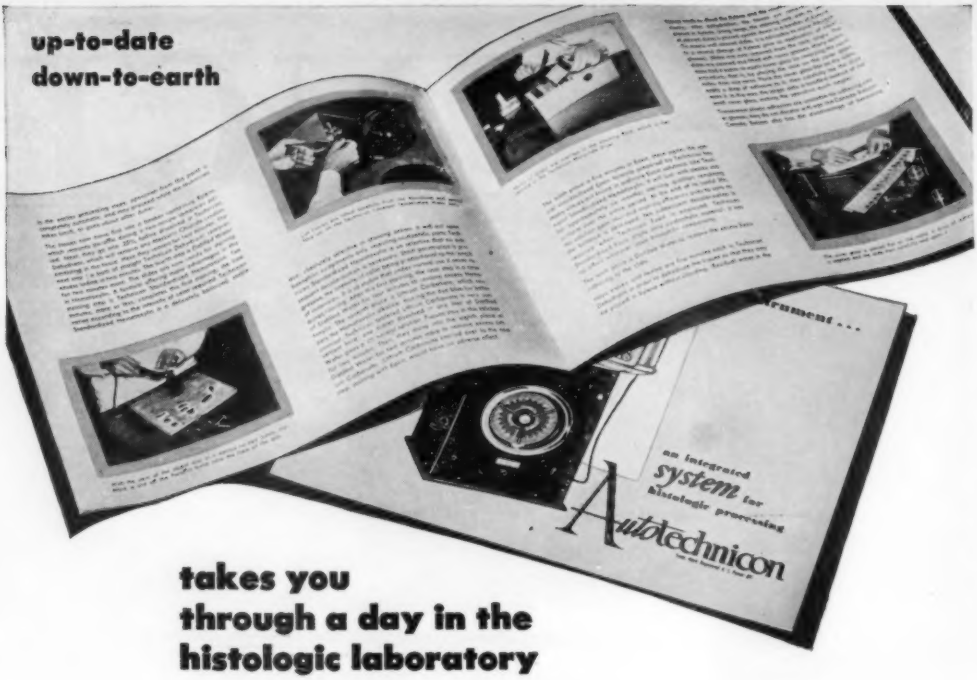

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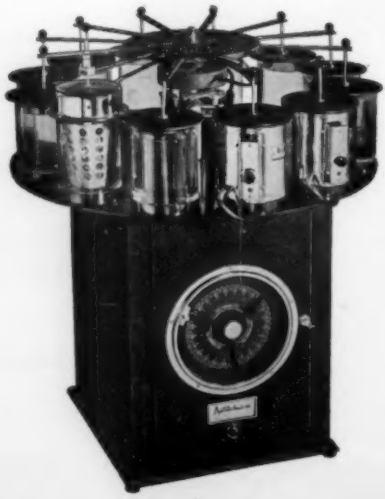

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The Solar Constant

STRICTLY defined, the solar constant is the total energy received in one minute upon a unit of surface perpendicular to the sun's rays, in free space at the earth's mean distance from the sun. It is usually expressed in langleys per minute, or the equivalent, gram-calories per square centimeter per minute.

Early in the present century the Astrophysical Observatory of the Smithsonian Institution, under the direction of the pioneer astrophysicist S. P. Langley, began a long-range study of the solar constant and its probable day-to-day variations. The classic work of Abbot and Fowle that followed—their development of instruments and methods, their search for satisfactory sky conditions, their studies of the absorption and scattering of radiation by water vapor, ozone, and dust—placed the solar constant research on a firm foundation.

In continuation of this Smithsonian project, there has now accumulated over a period of nearly 30 years a chronological record of solar constants computed from very specialized observations at high altitude stations in desert regions. The mean of these thousands of values is 1.946 langleys per minute. This mean, it should be noted, is not intended to express the absolute value of the solar constant, since the effort throughout has been to maintain a homogeneous series, preserving the original scale unchanged. The record indicates a surprisingly small, irregular variation, seldom exceeding a range of 2 per cent, with a gradual trend toward larger values. The total increase in the means of successive 5-year intervals is .3 per cent since 1925. The largest increase occurs in the 1946–50 interval, during which the number of sunspots reached a higher value than at any time since the year 1778.

The probable absolute value of the solar constant based upon this mean is largely determined by three factors: First, careful study indicates that the original arbitrary scale of radiation, which has since remained unchanged, is 1.8 per cent below the standard scale adopted by the Smithsonian in 1913. This conclusion is based upon a re-examination of all intercomparisons between pyrheliometers (instruments that measure total solar radiation at the observing station). Second, all comparisons since 1932 against the improved Smithsonian standard pyrheliometer agree in indicating that the correct scale of radiation (in true gram-calories) is 2.4 per cent below the adopted 1913 scale. Third, the corrections applied to the summation of energy in the observed region (wavelengths .34–2.4 μ) to allow for the unmeasured energy above and below this range need revision. New data from recent infrared studies and from V-2 rocket ultraviolet results indicate that the corrections applied should be increased by several per cent. One would assume that adding a percentage correction to the measured energy would proportionately increase the resultant solar constant. However, in the process of extrapolating the observations to zero air mass, there is an indirect compensatory factor that acts in the sense to diminish the effect of the increased corrections. From actual reductions of several typical long-method days, using a total ultraviolet plus infrared correction larger by 4 per cent of the observed energy, the solar constant is increased only .6 per cent.

Applying the three factors just mentioned (+1.8% to bring to the 1913 scale, −2.4% to reduce to true calories, and +.6% for larger ultraviolet and infrared corrections), the probable absolute value is, curiously enough, equal to the mean value 1.94. It is also identical with the solar constant that has been generally adopted in meteorological literature, based upon early Smithsonian results.

There is currently much interest in travel beyond the stratosphere. When this is accomplished, direct measurements of the solar constant, unhampered by an ever-changing and complex atmosphere, will follow.

L. B. ALDRICH
W. H. HOOVER

Astrophysical Observatory
Smithsonian Institution

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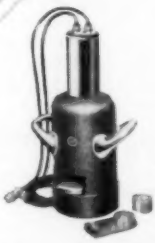

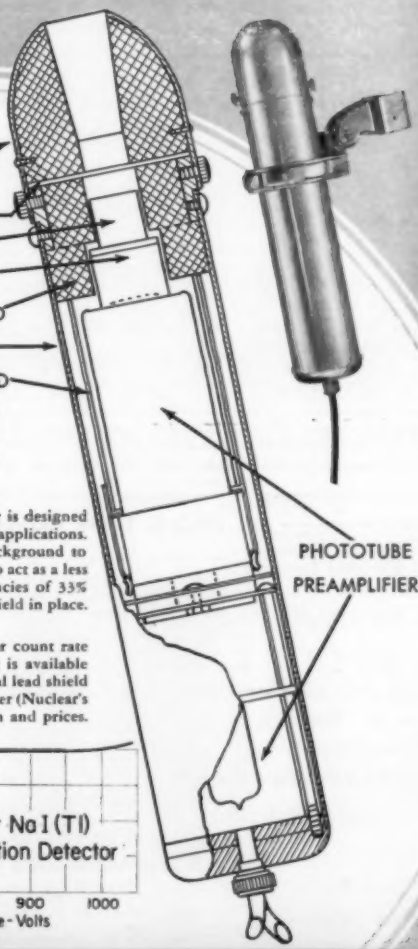

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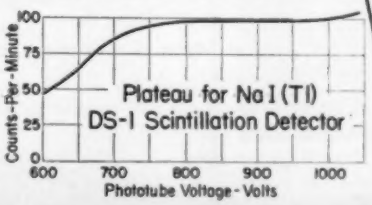

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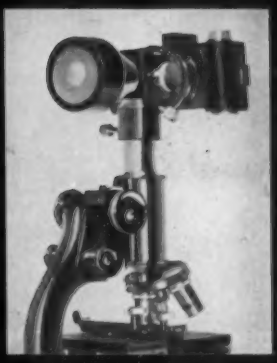

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The Recent Arvin-Tehachapi, Southern California, Earthquake[1]

John P. Buwalda and Pierre St. Amand
California Institute of Technology, Pasadena

THE STRONGEST EARTHQUAKE experienced in California since the San Francisco earthquake and fire of 1906 shook the southern end of the San Joaquin Valley on July 21, 1952. It was probably the largest seismic disturbance in the populated western portion of southern California since the Fort Tejon earthquake of 1857. Its magnitude was intermediate between the San Francisco earthquake and the more moderate shocks that occurred at Santa Barbara in 1925 and at Long Beach in 1933. On the Richter magnitude scale, which is designed to represent the energy of a shock, and on which the numbers are proportional to the logarithms of the square roots of the total energy dispersed by the earthquake waves during the shock, the magnitudes of the Arvin, San Francisco, and Long Beach disturbances were, roughly, 7.5, 8.2, and 6.3. The violence of shaking at a particular place is represented on the modified Mercalli scale, with the maximum figure XII indicating total destruction. Intensity naturally decreases with distance from the center of origin. This scale is based on human sensory impressions, disturbance of objects, or damage to buildings. It is believed that the Arvin shock reached an intensity of about X in the most heavily shaken zone.

The shock has been named the Arvin earthquake[2] because the center of the disturbance was much nearer to that town than to any other. Newspapers have called it the Tehachapi earthquake for the reason that damage in that community was more spectacular and was called to the attention of the newspapers first. Fourteen lives are known to have been lost in the July 21 Arvin shock, and two more persons were killed in a later disturbance at Bakersfield on August 22. The number of deaths was relatively small, considering the magnitude of the earthquake, because the fault along which the disturbance took place traverses territory in which no large towns are located. The section is mainly agricultural or pastoral and is relatively sparsely populated.

The shock was felt over a very large area. It shook the densely settled Los Angeles region about 80 miles to the southeast quite vigorously and alarmed the population. It was felt at San Diego and points farther south in Mexico, more than 200 miles away; at points north of San Francisco, roughly 300 miles to the northwest; and at Reno and in a large part of southwestern Nevada.

Property damage in the main Arvin and succeeding Bakersfield shocks has not yet been accurately estimated, but it will presumably total several tens of millions of dollars. As is usually the case in earthquakes in California, the damage to buildings was mainly in business and industrial structures rather than in residences. Brick and concrete-block parapet walls, cornices, store fronts, and side walls collapsed or fell outward when the buildings swayed. In some cases roofs dropped when the supporting walls fell away. These are the common types of earthquake failure. In the strongly shaken communities frame residences did not collapse or suffer material structural damage, but many lost brick chimneys, and had plaster badly cracked, and a few were shifted a few inches on their foundations, suffering rupture of water, gas, and sewage lines.

The town of Arvin is a young community of relatively new buildings, situated about four miles northwest of the earthquake-producing fault. Here, although more than half the business establishments on the main street suffered damage, none was damaged beyond repair. In Tehachapi, a larger and much older town in the Tehachapi Mountains, about 15 miles southeast of the fault, the damage was more severe; nearly all business structures were at least considerably damaged (Fig. 1), and a substantial fraction of them were completely wrecked. Nearly all the loss of life occurred here, most of it as a direct consequence of building collapse.

The greater destruction in Tehachapi, nearly four times as far from the fault trace as Arvin, can probably be ascribed mainly or entirely to the greater age and poorer construction of the buildings rather than to more violent shaking. In Bakersfield, about 19 miles northwest of the fault, and, like Arvin, situated on the flat floor of the deeply alluviated San Joaquin Valley, the damage from the July 21 earthquake was considerable but not severe. A much smaller second shock on July 29, originating on a fault only about 10 miles to the east, did some additional damage. The most extensive loss in Bakersfield resulted from a third earthquake on August 22. This shock badly damaged many business structures and caused some to collapse. Loss was severe along Chester Avenue, one of the older main north-south streets of the city. As usual, the failure was mainly in brick, stone, adobe, or concrete-block construction. There was slight damage on July

[1] Publications of the Division of the Geological Sciences, California Institute of Technology, Pasadena. Contribution No. 604.

[2] The name more recently settled upon for the shock is the Arvin-Tehachapi earthquake.

FIG. 1. Earthquake damage in Tehachapi, California, in shock of July 21, 1952. Illustrates a very common type of building failure in earthquakes: toppling outward or collapse of brick parapets, fronts, and side walls, which permits dropping of floors and roof trusses.

21 to buildings in Santa Barbara, about 65 miles southwest of the origin of the shock, as well as in Los Angeles, about 80 miles southeast of it.

The most severe loss in the Arvin earthquake was probably not in damage to buildings. In the southern end of the fertile San Joaquin Valley hundreds of miles of large concrete irrigation pipe buried in the fields were ruptured or telescoped by the earthquake waves. Concrete standpipes were sheared off at their bases, and the many large transformers serving the numerous deep-well irrigation pumps were toppled off their supports some 25 feet above the ground. There was considerable damage to the expensive wells and pumping equipment. Lower crop yields resulting from interruption of water supply during the height of the growing season will doubtless cause great losses.

In the extensive oil operations of the area affected by the shock, damage to oil wells and pumping equipment was not great, but oil, gasoline, and gas pipelines suffered severely from rupture or telescoping. High-pressure pumping plants and equipment of the various oil companies in the strongly shaken area were badly damaged. Large oil tanks resting on the ground settled, warped, and developed leaks. Smaller oil and water tanks mounted on elevated timber platforms crushed their supports, falling to the ground in the general direction of the fault, regardless of the side of the fault on which they were located.

Lurching in the deep alluvium of the San Joaquin Valley led to unequal settling, cracking, humping, and local horizontal shifting of the ground, with resulting damage to highway pavements, bridge approaches, irrigation reservoirs, and ditch systems.

The Valley Line of the Southern Pacific Railroad, used in this section jointly with the Atchison, Topeka & Santa Fe, crosses the fault zone three times in the course of a switchback, making a pattern with the fault zone resembling a dollar sign. Four tunnels in this loop were severely damaged and rendered unusable. In a frantic three-week effort to reopen the line to traffic, marked by epoch-making records in rates of excavation and fill, two of the tunnels and part of a third were converted to open cuts, and the fourth bore was by-passed with a shoofly track and is now being repaired.

The Arvin earthquake and succeeding shocks have been, and are still being, thoroughly investigated, both geologically and seismologically. In the field the very extensive and complex fracture pattern developed in the earthquake belt has been minutely studied and mapped, especially by the authors. The staff of the Seismological Laboratory, Drs. Gutenberg (director), Benioff, and Richter, with several assistants, have been analyzing a wealth of excellent seismographic records from approximately a dozen permanent stations of the California Institute of Technology, from stations of the U. S. Coast and Geodetic Survey scattered over southern California and Nevada, and from the several portable installations rushed immediately into the earthquake zone to record the hundreds of aftershocks, which are still continuing.

The Arvin earthquake originated through slip, not on the well-known San Andreas fault, which runs the length of the west side of California, or on any of the other northwest-southeast strike-slip faults long recognized as active, but on White Wolf fault (Fig. 2).

This important fracture trends northeast-southwest across the south end of the San Joaquin Valley, at right angles to the valley and to the San Andreas fault. It is roughly parallel to Garlock fault, a fracture on the opposite, or southeastern, side of the Tehachapi Mountains, which branches off the San Andreas near Tejon Pass and extends some 160 miles eastward to the south end of Death Valley. The known length of White Wolf fault is about 30 miles. It seems to have been first recognized by Lawson (*1*) half a century ago and was given its present name by Hoots (*2*). The habitual direction of slip on this fault in past geologic time is not definitely known, but its movement has had a vertical component that lifted the southeast side many thousands of feet relative to the block northwest of it. There is reason to believe that the fault is a thrust dipping steeply or moderately to the southeast.

To the southwest, approximately half the length of the fault lies beneath the alluvium of the San Joaquin Valley and has no surface expression, but it is conspicuously shown on geophysical (seismic reflection) maps. Data kindly made available by Rollin Eckis, chief geologist of the Richfield Oil Corporation of Los Angeles, indicate that the fault is known to continue its nearly straight S50°W course to within about 3 miles of the east-west north-facing scarp of Wheeler Ridge. The ridge is a sharp fold, overturned toward the north and cut by a south-dipping thrust, but the relation of White Wolf fault to this structure is not known. A narrow zone of long cracks crosses the higher part of Wheeler Ridge obliquely to its long axis, paralleling White Wolf fault almost exactly where the projection of the fault would cut the ridge. Similar cracks are not known on other parts of the ridge.

The Richfield maps show that on the southeast side of the fault, near its known southwestern end, the top of the Santa Margarita formation (upper Miocene) is at 4000 feet below sea level, whereas on the northwest side and two miles away the same horizon lies at −15,000 feet. One mile southwest of Comanche Point (Tejon Hills) the Santa Margarita is at −3000 feet on the southeast side of the fault, and at −12,000 feet less than a mile away on the northwest side. On Wheeler Ridge itself the same formation is 1000 feet above sea level, but two miles to the north it is at −14,000 feet; four miles to the north it is at −16,000 feet. Mr. Eckis states that in drilling along the northwest side of the fault steeply dipping and vertical beds are encountered to depths of thousands of feet, presumably dragged up by the fault movement.

About five miles south of Arvin the fault, still beneath alluvium, cuts off the northwest-trending structures in the Tertiary formations of the Tejon Hills. About four miles east of Arvin a system of surface ruptures begins and extends northeastward for some 18 miles along the hilly lower slopes of the great northwest-facing scarp of Bear Mountain and approximately along the presumed locus of White Wolf fault. In this stretch the surface rocks are mainly diorite, with a mantle of soil and disintegrated and decomposed rock. The lower half or more of the Bear Mountain scarp, which attains nearly 5000 feet in height, has suffered extensive landsliding, which has formed many ridges trending roughly parallel to the slope instead of extending up and down it, as well as closed or nearly closed basins behind (or uphill from) the ridges; has diverted streams for hundreds of feet to right or left of their original positions; and has shattered and crushed practically all the surface rock. These landslides had rather completely masked the location of White Wolf fault before the earthquake. Its location is not now evident, except that a zone of ruptures a fraction of a mile wide presumably marks the general position of the trace.

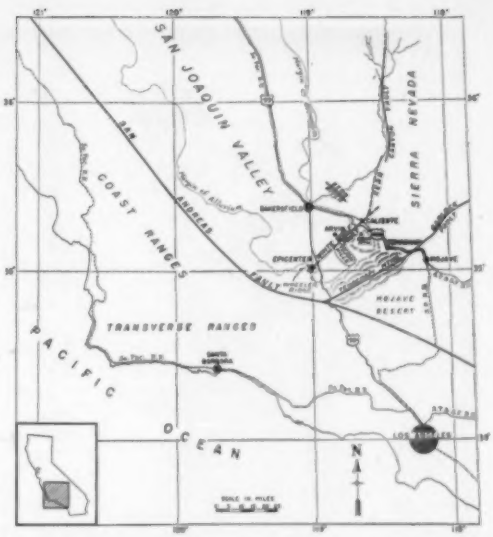

FIG. 2. Map of part of southern California showing some of the principal faults, White Wolf fault on which the earthquake originated, and location of epicenter.

It has been suspected for a long time that the Kern Canyon fault, which is followed for more than 70 miles by the south-flowing main fork of Kern River from north of Mount Whitney to Kernville, continued southward and southwestward to join or become White Wolf fault. It probably continues southward to an intersection or union with it, but it now appears from the northeastward persistence of the ground-rupture system and the distribution of aftershocks that White Wolf fault continues on its own course for at least some miles northeastward beyond the presumed point of intersection. It may go to upper Harper Canyon or beyond.

The epicenter of the main Arvin earthquake was approximately at Wheeler Ridge, at or near the known southwest end of White Wolf fault. From this initial point of rupture the fault slip apparently progressed rapidly northeastward and only in that direction, for all or practically all the hundreds of aftershocks originated northeast of the epicenter of the main

FIG. 3. One of the wider cracks in alluvium caused by the earthquake. On crest of ridge between Tehachapi and Caliente creeks, in fault zone. Photo by Southern Pacific Railroad.

shock. Perhaps of equal significance is the fact that the only foreshock, preceding the main shock by a few hours, occurred a short distance southwest of the main epicenter. Aftershocks can, of course, be expected to continue for several more months.

A strong earthquake is usually followed by a train of aftershocks that decrease in average frequency and in magnitude. In some cases a strong shock apparently unbalances crustal strains in the region in such a way that further relief by fault slip is soon necessary. The Arvin shock seems to have been in this category. Following the main July 21 earthquake, a second shock, on July 29—weaker but still moderately strong, and comparable to the Long Beach earthquake of 1933—originated 10 miles east of Bakersfield and did some additional damage in that city. Its focus may well have been on the northwest-southeast Kern River fault, which trends at right angles to White Wolf fault. On August 22 a third shock of comparable magnitude but originating only about five miles east of Bakersfield caused serious damage in that city—far more than either of the preceding earthquakes and estimated to be as high as $20,000,000. Each of these two later shocks had its own train of aftershocks. On August 20 a strong shock (magnitude greater than 7.0) originated on the San Andreas fault near the known northern end of its active belt off the southwestern Oregon coast. On August 23 another earthquake, of magnitude 4.5, occurred on or near the San Andreas between Palmdale and Elizabeth Lake, with its epicenter about 50 miles southeast of that of the Arvin shock. All four of these disturbances on faults other than White Wolf could, of course, be unrelated to the Arvin earthquake, but they are probably sympathetic and are the result of readjustments in the stress pattern in the fault net of the state. In the southern San Joaquin Valley region this net consists mainly of intersecting faults trending northeast-southwest, east-west, and northwest-southeast.

Several of the stronger earthquakes in the Southwest have been accompanied by the development of long and continuous surface traces of the originating faults, with vertical or horizontal offset of the land surface, roads, fences, streams, property lines, and other features. No such simple, continuous rupture resulted from the slip on White Wolf fault during the Arvin earthquake, and the writers have not seen much evidence of earlier scarplets or fault troughs. Although numerous fractures, long and short, of a variety of types occur, it is not certain that any one of them is actually the trace or outcrop at the surface of the main White Wolf fault. What, then, was the nature of the surface distortion where the fault plane, rising from a depth of at least 10 or 15 miles, intersects the landscape? So far as known, it caused no visible surface distortion on the flat alluvial floor of the San Joaquin Valley. In the hilly diorite or granite country between Arvin and some point north of Caliente, mostly along the base of the Bear Mountain scarp, a zone of ruptures a fraction of a mile in width marks the supposed course of the fault. Some ruptures are simply cracks (Fig. 3) roughly parallel to the fault zone (trending N50°E), fractions of an inch to inches in width, but locally one to three feet wide. They may or may not show horizontal or vertical displacement—usually in terms of inches, rarely a foot or two. The uplifted side

FIG. 4. Typical *en échelon* cracks, indicating left-hand horizontal shearing movement. Near Tunnel 5 of Southern Pacific Railroad.

FIG. 5. Diagram of open *en échelon* cracks in alluvium caused by the Arvin earthquake and found at many places along the northeastern half of the fault. Inference of horizontal displacement on the cracks is corroborated by offsets of fences, roads, and trails.

is usually on the uphill side, but this is commonly reversed. The cracks apparently indicate tension. In places the cracks, which are crescentic in plan with the horns pointing downhill, appear to be the upper boundaries of large surface masses sliding downhill and pulling away from the surface material uphill from them. Many of the cracks are discontinuous and overlapping, oblique to the zone of cracks; they are *en échelon* (Fig. 4). These are believed to have resulted from horizontal shear, and the orientation of the open cracks with reference to the zone is thought to indicate the direction of shear and movement (described as left-hand when the mass on the other side of the zone or fault has shifted horizontally to the left with reference to the side on which the observer is standing [Fig. 5]). Left-hand movement seems to be much more common than right-hand, but right-hand and left-hand movements were noted at different places on the same long lines or zones of cracks. Another surface feature is the so-called mole track, a crooked, compressional ridge formed by humping up or buckling of the soil to a height measurable in inches or, at most, a foot or two (Fig. 6). Miniature overthrusts commonly accompany the mole tracks; they may dip either downhill away from Bear Mountain or toward it. They tend to be *en échelon*, indicating both compression and horizontal shear, either right- or left-hand. Rupture lines or zones two or three miles in length, which contains all these features, have been taken by many geologists to be actual traces of White Wolf fault. A rupture line may extend for hundreds or thousands of feet along the base of steep slopes, then it may go obliquely up over a high ridge, bearing no relation to topography. It may stand steeply where it crosses one canyon, but follow the contours horizontally back into the next canyon. At its end it may turn up the mountain face and rise one or two thousand feet before terminating. Some zones of cracks are found only along the crests of high wide ridges, as though the soil mantle had been shaken downhill on both slopes. The mole tracks—pressure ridges—are found most commonly along the bases of scarps and ridges. To complicate the pattern there are three or four rupture lines about two miles in length which extend from points on the Bear Mountain scarp across the presumed location of White Wolf fault out into the flat or gently rolling country to the northwest, with almost exactly north-south trends, making angles of about 50° with the main fault zone.

FIG. 6. Typical mole track, or compression ridge, in alluvium about four miles east of Arvin, California, viewed southwest toward point in east margin of alluvium of San Joaquin Valley, where long cracks and mole tracks end. Mole track at this point actually consists of *en échelon* mole tracks (seen in foreground to left of figures), indicating right-hand horizontal movement as well as compression. Block to left of mole track has risen about two feet with reference to block on its right.

In the enormous cuts made by the Southern Pacific Railroad to replace the tunnels, it appears that the mole tracks on the landscape above the cuts are connected with old fractures or minor faults in the bedrock. In one of these fractures, dipping about 28° to the southeast and striking roughly parallel to White Wolf fault, old crystalline rock has overridden Quaternary gravel of the adjacent Clear Creek and old soil that accumulated on it. At or near this point the railroad track was shortened some eight feet by kinking (Figs. 7, 8). This looks like an overthrust fault, but it could equally well be a fracture at the base of a huge landslide. In spite of the low dip of the fracture, the movement on it as indicated by slickensides was horizontal; it is a strike slip. During the month of August the upper block moved northeastward two inches horizontally, as indicated by markers on the west side of the cut south of Tunnel 3. The post-earthquake movement and its direction can be reconciled better with landsliding on a huge scale than with faulting, but in this article it is not possible to discuss more of the characteristics of the fracture pattern than suffice to indicate its complexity. Full tectonic implications can come only by eventually combining all the geologic, structural, and seismological data. At this stage it is perhaps advisable to do no more than draw the following preliminary and probable inferences: (1) White Wolf fault, lacking such features as sag-ponds, offset streams, etc., is not a strike-slip fault of the San Andreas type. (2) It has experienced huge vertical dislocation in past geologic time, as evidenced by the high scarp of Bear Mountain and the buried structure along it beneath the alluvium of the San Joaquin Valley; hence the southeast side of the fault presumably rose during this earthquake. (3) Its straight course suggests that it is steep or vertical in

FIG. 7. View north toward the south end of Tunnel 3 of the Southern Pacific Railroad, showing part of damage to tunnel where one of the long cracks crossed the bore near its portal at a large angle. Also shows sharp kinking and presumed shortening of track by some eight feet, part of which occurs beyond white waste pile within tunnel.

FIG. 8. View into south end of Tunnel 3, showing kinking of track and damage to reinforced concrete tunnel walls, which here were pushed inward over kinked rails.

attitude but, if not, the buried fold in the sedimentary rocks under the valley suggests that it is a thrust fault dipping southeastward. (4) Comparing the magnitude of the earthquake with others in the Southwest for which the fault displacement was observed, the slip on White Wolf fault during this shock was probably 5–15 feet in the bedrock at depth. (5) The dislocation on the fault did not develop a single or simple continuous surface trace, as in many other earthquakes, but the complex rupture pattern, with its variety of fracture types, trends, and directions of displacement, is probably largely or wholly the result of shaking combined with gravity acting on small to huge earth masses, many of them blocked out by previous earth-mass movements, or it may represent relief of strain by distribution of the movement over a wide zone of incompetent material, utilizing smaller preexisting faults for this purpose.

In recent years Benioff has made intensive studies of elastic strain rebound characteristics. He thinks (*3*) that the aftershock sequence of the Arvin earthquake is such as to indicate that the strain relieved by the earthquake was mainly of the compressional type rather than the shearing type so common in Coast Range shocks.

In spite of textbook generalizations, earthquakes are found to differ greatly among themselves when studied carefully, and the Arvin shock exhibited several unique, or at least remarkable, characteristics. Although a large earthquake, it did not develop the common type of surface trace. The fault appears remarkably straight for a fault that is not of the strike-slip type. The earthquake occurred on a fault which, so far as known to the writers, has little or none of the evidence of recent activity along it usually associated with active faults in California. Considering the magnitude or energy output of the earthquake, its destructiveness appears to have been surprisingly low. The vigor of shaking seems to have been unsymmetrically disposed about the fault, in that the violence at Tehachapi and the Women's Prison, 12–16 miles away, was apparently not very different from that at Arvin, only about one fourth the distance from the fault and located on at least as great a thickness of alluvium. As mentioned earlier, all or virtually all the aftershocks occurred northeast of the epicenter of the main shock, whereas the one foreshock was apparently southwest of it. Most of the springs in the strongly shaken region increased their flow two- to fourfold, but some ceased to flow; streams normally dry in summer developed large flows of water within a few days, presumably after discharge from the bedrock had saturated the bed gravels; Caliente Creek above Caliente, normally dry in midsummer, was flowing an estimated 20 cubic feet per second on August 20, 1952.

The Arvin earthquake taught the same lesson that shocks in different parts of the world have taught humanity for decades: that earthquakes, per se, rarely harm anyone; that structures designed to be earthquake-resistant suffer little or not at all, whereas walls, parapets, and building fronts made of brick, adobe, or concrete blocks that are not reinforced with steel and tied securely to the remainder of the building collapse or fall outward, harming persons near them and permitting the interiors of the structures to fall. From comparisons of the behavior of different types of buildings in numerous shocks, it is perfectly evident that the solution of the earthquake problem is simply to build wisely by choosing proper design and appropriate materials. Fortunately this can be done with little added cost. Safety from earthquakes is more easily attainable than safety from floods, tornadoes, hurricanes, and some other natural hazards.

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News and Notes

AIBS Meetings at Cornell University

THE American Institute of Biological Sciences sponsored its third campus meeting for biologists at Cornell University on Sept. 8–10. Through a combination of factors—not the least being the geographic location, the Cornell tradition in the biosciences, and the variety of biological disciplines represented by the 24 participating societies—the meetings broke all records in attendance. It was undoubtedly the largest gathering of biologists ever to assemble in an American university setting. The 4000—and more—who attended could not fail to be inspired by the obvious fact that biologists are numerically becoming an important factor in American science. Cornell is to be congratulated on its resourcefulness and hospitality in accommodating so large a group.

The great diversity of interests that exist even within the field of the biological sciences was demonstrated by the societies meeting at Cornell. General biology, botany, and zoology were represented by the American Society of Naturalists, the American Society of Zoologists, the Botanical Society of America, and the National Association of Biology Teachers. Taxonomy, morphology, anatomy, and field study were represented by the American Bryological Society, the Fern Society, the Society of Plant Taxonomists, the Mycological Society of America, the Phycological Society, and the Society of Protozoologists. Plant diseases and pathogenic organisms occupied the interest of the American Phytopathological Society and the American Society of Parasitologists. Crop and ornamental plants were the focus for members of the American Society for Horticultural Science. Genetics in all its aspects was the concern of the Genetics Society of America and the American Society of Human Genetics. Microbiology was represented by the Society for Industrial Microbiology; microscopy, by the American Microscopical Society; fresh and salt-water biology, by the American Society of Limnology and Oceanography; physiology, by the American Society of Plant Physiologists and the Society of General Physiologists; ecology, by the Ecological Society of America; and evolution, by the Society for the Study of Evolution.

An important aspect of a joint meeting of societies is the opportunity it presents of cooperating in symposia and panel discussions that cover overlapping fields of interest. A great number of symposia sponsored by two or more societies were a feature of the Cornell meeting.

Symposia on "Nitrogen Metabolism in Plants" and "Herbicidal Action of Chemicals" were given jointly by the American Society for Horticultural Science, the American Society of Plant Physiologists, and the Botanical Society of America. "Plot Techniques in Horticultural Research" was presented by the American Society for Horticultural Science and the Biometric Society of Eastern North America. "Biochemical Evolution" was sponsored by four societies: the American Society of Naturalists, the Society for the Study of Evolution, the Genetics Society of America, and the American Society of Zoologists. A symposium on "Teaching of Ecology in Urban Areas" was arranged by the Ecological Society of America and the American Society of Zoologists. The "Life Cycle of an Angiosperm" was presented by both the Botanical Society of America and the Ecological Society of America. Symposia within societies included: "Modern Methods of Microscopy" (American Microscopical Society); "Disease Resistance in Plants," "Plant Parasitic Nematodes," "Physiology of Parasitism," and "Antibiotics" (American Phytopathological Society); "Genetics of Various Constitutional Defects and Counselling Clinics in Human Heredity" (American Society of Human Genetics); "Undergraduate Training of Professional Botanists" (Botanical Society of America); "Evolution of Tissue Systems in Plants" (Society for the Study of Evolution); "Teaching the Anatomical Sciences at the Undergraduate Level" (American Society of Zoologists); and "Plant Genera, their Nature and Definition" (American Society of Plant Taxonomists).

Presidential addresses at the numerous society dinners, as well as lectures by invited biologists, provided an additional source of inspiration beyond the limited areas of individual specialization. Among them were the Characteristics of Certain Species of Actinomycetes, by B. M. Duggar; the Geological History and Evolution of Insects, by F. M. Carpenter, presented by Sigma Xi; Human Genetics as a Science, as a Profession, and as a Social-minded Trend of Orientation, by F. J. Kallmann; Gene and Organism, by Sewall Wright; the Size of Nuclei and Cells, by Franz Schrader; Biotic Communities of North America, by S. Charles Kendeigh; Plant Anatomy in the Service of other Botanical Sciences, by Katherine Esau.

The more rugged members of the several societies participated in numerous trips and forays to observe at firsthand the biota of the Finger Lake district. Paleobotanists pried loose the secrets of the Devonian shales adjacent to Cayuga and Canandaigua lakes. Phycologists scanned the cliffs surrounding Buttermilk Falls in their search for algae. Limnologists examined the aquatic communities of the local lakes and glens. Bryologists scrambled through the Junius bog in their search for mosses and liverworts. Mycologists went all-out for a three-day inspection of Coy Glen, Michigan Hollow, and the Lloyd-Cornell preserves.

No report of a convention would be complete without the statistical data that give a quantitative evaluation of the meeting. Some 3200 registered as participants in the meetings. To these can be added the 800

or more registered guests and wives. A breakdown of the registration reveals the cosmopolitan nature of the AIBS-sponsored meetings. Forty-seven states, the District of Columbia, Alaska, and Hawaii were represented, and Canada participated 165 strong. Representatives of 23 other foreign countries were also present: among them, South Africa, Australia, Austria, Belgium, Bolivia, Brazil, China, Egypt, England, France, Honduras, India, Iran, Israel, Italy, Japan, the Netherlands, Norway, New Zealand, and Switzerland.

The general program listed 1392 papers, of which approximately 100 were read by title. It is interesting to note that every state except Idaho was represented by a biologist giving a paper at some society meeting. As might be expected, New York led with 163 papers; surprising (except to Californians) were the 99 papers from California; Maryland came in third with 96. Then followed Illinois with 81, Michigan and Massachusetts each with 75. Twenty-five or more titles came from each of the following: Wisconsin, Indiana, Ohio, Connecticut, Iowa, Missouri, Minnesota, Pennsylvania, Texas, New Jersey, Florida, North Carolina, and Washington.

The local chapter of Sigma Xi gave a tea in Willard Straight Hall for all those present on the Sunday before the meetings began. A tour to the Corning Glass Center was well attended. A luncheon given by the Governing Board of AIBS for the presidents of the 24 participating groups brought together a representative segment of American biology for a social, as well as an informative, event. The Biologists' Smoker, held the final evening in Barton Hall, was a gala affair, where one could find almost every biologist who attended the sessions.

In the background at Cornell were members of the Ohio State and Minnesota local committees, enjoying a meeting while reminiscing of their hectic moments in 1950 and 1951. In the foreground were members of the newly chosen Wisconsin local committee, taking notes for the 1953 meeting and making sure that the fourth AIBS-sponsored meeting, at the University of Wisconsin, will be another memorable event for biologists.

CLARENCE J. HYLANDER

Convention Director, AIBS

Scientists in the News

J. E. Ackert, dean emeritus of Kansas State College graduate school, has accepted an invitation to lecture on parasitology in Brazil from July to November 1953 on invitation of the Brazilian Ministry of Foreign Relations. He is resigning as a delegate of the American Society of Parasitologists to the International Zoological Congress in Copenhagen in August and to the International Congress of Tropical Medicine in Istanbul in September.

Robert Adler has been appointed associate director of research for Zenith Radio Corporation. Dr. Adler joined Zenith in 1941 as a member of the corporation's research division.

Hans Borei, head of the Department of Biophysics of the Wenner-Gren Institute, Stockholm, and associate professor of biology in the University of Stockholm, has been apointed professor of zoology in the University of Pennsylvania, beginning Jan. 1. Dr. Borei will carry on work in experimental zoology along biochemical and biophysical lines, including chemical embryology.

W. S. Bullough, cancer research fellow and honorary lecturer in zoology in the University of Sheffield, has been appointed to the chair of zoology at Birkbeck College, University of London. Dr. Bullough was lecturer in zoology at McGill University, Montreal. He returned to Britain as Sorby fellow of the Royal Society, a post held with that of honorary lecturer in zoology at the University of Sheffield. He was awarded a Senior Cancer Research Fellowship in 1951, and he now takes the chair formerly occupied by **A. Graham.**

Charles G. Child 3d has been appointed surgeon-in-chief of the New England Center Hospital–Pratt Diagnostic Clinic, and professor of surgery at the Tufts College Medical School. Dr. Child is associate professor of clinical surgery at Cornell University Medical College and attending surgeon at the New York Hospital. He begins his new duties in Boston in January.

Richard S. Davidson has joined the administrative staff of Battelle Institute to coordinate relations between Battelle and its sponsors of agricultural and biological research. Until recently Dr. Davidson was a member of the faculty of Alabama Polytechnic Institute.

The Commonwealth Scientific and Industrial Research Organization reports the appointment of **C. W. Emmens,** professor of veterinary physiology, as officer-in-charge of its new Sheep Biology Laboratory at Prospect near Parramatta, New South Wales. Professor Emmens will continue concurrently his work as professor of veterinary physiology at the University of Sydney.

Roland Fischer, formerly connected with the University of Basel and later with the National Research Council of Canada, has joined the Psychiatric Research Unit of the Public Health Service of Saskatchewan at Regina General Hospital, where he is in charge of the biochemical and biological research laboratory.

P. C. C. Garnham, who was in the Colonial Medical Service from 1925 to 1947 and has since been on the staff of the London School of Hygiene and Tropical Medicine, University of London, has succeeded **H. E. Shortt** in the chair of medical zoology in that institution. In 1951 Drs. Shortt and Garnham were jointly awarded the Darling Medal and Prize by the World

Health Organization for their research on the life cycle of malaria parasites.

Donald Lincoln Herr has been elected president and a director of American Electronic Mfg., Inc., Los Angeles.

G. Evelyn Hutchinson, director of Graduate Studies in Zoology at Yale, has been awarded the Leidy Medal by the Academy of Natural Sciences of Philadelphia. Given every three years in memory of Joseph Leidy, the medal was established by the academy in 1925.

Shirley A. Johnson, Jr., mechanical engineer and physical scientist, has been named acting director of the Institute of Industrial Research at the University of Denver. He will remain in the post, recently vacated by **George O. G. Löf,** until a permanent successor is found. Mr. Johnson has served as assistant director of the institute since 1947.

William M. Leeson has been appointed director of the West Virginia University Arboretum–Plantations, established Aug. 4, 1948, on a 260-acre tract of land acquired by the university for expansion of the campus.

Ely Mencher, formerly senior field geologist and research geologist with the Socony-Vacuum Oil Company of Venezuela, has been appointed associate professor of geology in the Department of Geology and Geophysics at Massachusetts Institute of Technology. At MIT Dr. Mencher will conduct courses in stratigraphy and petroleum geology and will continue his research on the geology of South America.

John Minot has been appointed head of the Department of Biological Sciences at Dean Academy and Junior College, Franklin, Mass.

William Branch Porter, professor of medicine, Medical College of Virginia, was honored by his former residents by the founding of the William Branch Porter Society. A scroll presented to Dr. Porter read: "In recognition of his many years of devoted service, unfailing interest, and inspirational teaching as professor of medicine at the Medical College of Virginia, we, his former residents, honor our esteemed teacher . . . by founding the William Branch Porter Society."

Charles A. Rietz has been appointed to the position of research and development director of Interchemical Corporation, Printing Ink Division, and will make his office at the divisional headquarters office in New York. Formerly manager of the corporation's Eastern District printing ink factory in Elizabeth, N. J., Mr. Rietz joined Interchemical in 1927 in Chicago as a chemical engineer. **Victor J. Porth, Jr.,** is the new manager at Interchemical's Elizabeth factory. He was formerly head of the Product Development Laboratory at the Chicago factory.

David Sarnoff, chairman of the board of the Radio Corporation of America, has been named the first recipient of the newly established **Founders Award** by the Institute of Radio Engineers. The award was given "for outstanding contributions to the radio engineering profession through wise and courageous leadership in the planning and administration of technical developments which have greatly increased the impact of electronics on the public welfare." **Robert M. Page,** superintendent of Radio Division III and associate to the director of research of the U. S. Naval Research Laboratory, Washington, D. C., was named the recipient of the 1953 Harry Diamond Memorial Award, given annually to a person in government service, for his "outstanding contributions to the development of radar through pioneering work and through sustained efforts over the years." The 1953 Browder J. Thompson Memorial Prize will be awarded to **Richard C. Booton, Jr.,** MIT, for his paper entitled, "An Optimization Theory for Time-Varying Linear Systems with Non-stationary Statistical Inputs," which appeared in the *Proceedings of the I.R.E.* The award is bestowed annually on an author under 30 whose paper constitutes the best combination of technical contribution and presentation of the subject. **Edward O. Johnson** and **William M. Webster, Jr.,** RCA Laboratories Division, Princeton, N. J., were named recipients of the 1953 Editor's Award.

Cleon O. Swayzee has been appointed director of research for the Board on Overseas Training and Research, established early this year as an advisory body by the Ford Foundation. Dr. Swayzee was formerly chief of the Division of International Labor and Social Affairs, Department of State.

Francis J. Turner, professor of geology on the Berkeley campus, recently represented the University of California at the meeting of the International Geological Congress in Algiers, where he presented a scientific paper.

Sten Wahlund, of the University of Stockholm, has been commissioned by the United Nations to assist the Indian government in carrying out a large-scale demographic study to ascertain to what extent the application of the so-called rhythm method influences the birth rate.

Education

The **American Association of University Women,** at an estimated cost of $123,000, will support the studies of 54 women from 20 countries in various U. S. colleges during 1952–53, seventh year of the program. The expense is met each year by voluntary contributions from association members.

The **Hertzstein Medical Lectures** at Stanford University School of Medicine are being delivered by William Barry Wood, Jr., Busch professor of medicine at the Washington University School of Medicine. Speaking Dec. 8, 10, and 12, Dr. Wood is discussing "The Cellular Immunology of Acute Bacterial Infections." The lectures, established in 1929 by

the late Dr. Herzstein, of San Francisco, are given in alternate years.

New York State College of Agriculture, Cornell University, has been host to George L. McNew, director of the Boyce Thompson Institute for Horticultural Research. During his visit, which will end Dec. 18, Dr. McNew is giving a series of ten lectures on soil fertility and plant disease.

The **University of Vermont** has appointed Durwood J. Smith, of the University of Rochester, professor of pharmacology and chairman of the department in the College of Medicine; he succeeds N. B. Dreyer, who is now at Women's Medical College of Philadelphia. Dorothy Jackson Morrow has been appointed instructor in the Division of Pediatrics.

Grants and Fellowships

The 1953 **David Anderson-Berry Prize** will be awarded by the Royal Society of Edinburgh to the person who, in the opinion of the council, has recently produced the best work on the therapeutical effect of x-rays on human diseases. Both published and unpublished work is eligible, and applications must be in the hands of the society's general secretary, 22 George St., Edinburgh 2, not later than *Mar. 31.*

Humble Oil & Refining Company has increased its graduate fellowships from 12 to 20 for 1952–53, and has added three new schools at which fellowships are available: a fellowship in geology at the University of California, Los Angeles; in chemical engineering at Georgia Tech; and in basic and applied physics at Alabama Polytechnic. Selection of recipients is entirely in the hands of the institution staffs.

Graduate assistantships, paying $1000–$1200, are available at **Lehigh University.** Also available in most of the engineering and science departments are research assistantships paying $100–$180 per month. Inquiries for either should be addressed to the head of the department concerned. Information concerning scholarships and fellowships (for which applications should be submitted by *Mar. 1*) may be obtained from the Admissions Office.

The **Nutrition Foundation, Inc.,** has approved grants totaling $93,000 in addition to earlier grants for 1953 totaling $162,500. Largest amount ($19,500) went to Washington University for the support of work by Oliver Lowry; the Institute of Nutrition of Central America and Panama received $7000 for the work of Nevin S. Scrimshaw; and $33,800 was allocated to educational work.

Vick Chemical Company will award research fellowships to two graduate students at the School of Pharmacy, University of North Carolina. Work will be done under the direction of E. A. Brecht.

Wisconsin Alumni Research Foundation assistantships are available in the natural sciences and in engineering. Stipends are $1500 for July 1 to June 30, with one month's vacation. Applications must be filed with C. A. Elvehjem, Graduate School, University of Wisconsin, by *Feb. 15.*

In the Laboratories

Beckman & Whitley, Inc., San Carlos, Calif., has appointed Joseph B. Rice, Jr., general manager and chairman of the board. Mr. Rice was formerly with Beckman Instruments, Inc. The two companies are not related.

Goodrich-Gulf Chemicals, Inc., has been organized by Gulf Oil and B. F. Goodrich for the exploration of projects in the petrochemicals field. Main office will be in Pittsburgh, with a plant located at Orange, Texas.

New **Arthur D. Little** staff members include Garth A. Abott, of General Electric Company, Lynn, Mass.; Jay Joseph Martin, Jr., former chief of the Engineering Design and Inspection Branch at Picatinny Arsenal; and Donald Guild, of Rodney Hunt Co.

A $1,000,000 **Phoenix Memorial Laboratory** for atomic research will be built on the University of Michigan's new North Campus. Funds were raised through the Michigan Memorial–Phoenix Project.

The **Portland Cement Association** has opened an office in Helena, Mont., with Jack Y. Barnes as district engineer in charge.

Wakefield Industries, Inc., Skokie, Ill., has acquired the **Del-Mar Scientific Glass Company,** of Chicago. The combined companies will be located in Wakefield's new plant in Skokie.

Miscellaneous

The **American Academy of Arts and Sciences** will award its Rumford Medals for outstanding contributions in the field of heat and light to the following: Enrico Fermi, for his studies of radiation theory and nuclear energy; Willis E. Lamb, Jr., for his studies of the atomic hydrogen spectrum; Lars Onsager for his contribution to the thermodynamics of irreversible flow. The medals will be awarded in Boston Mar. 26–28 at a meeting to be held by the academy in celebration of the bicentennial of the birth of Count Rumford.

The **Association of American Railroads** has awarded a two-year contract to the Franklin Institute Laboratories for Research and Development to investigate materials used in freight car axle bearings. The project will be under the direction of F. S. Chaplin.

Case Institute of Technology and **Western Reserve University** will dedicate a memorial plaque Dec. 19, the 100th anniversary of the birth of Albert A. Michelson, near the spot where in July 1887 Dr. Michelson and Edward W. Morley conducted the Michelson-Morley experiment.

Rosa Goldstein, first woman to receive a Ph.D. degree from Cambridge University, has been visiting the U. S. on behalf of **Haifa Technion,** Israel's only

institute of technology. At a news conference in Washington, D. C., she mentioned current lack of space and deficiencies in the curriculum. She pointed out that 30 engineers are needed for a $2,000,000 Huleh swamp clearance project. Numerous openings for one- and two-year and permanent positions are listed with the American Technion Society, 80 Fifth Ave., New York.

The **Waksman Foundation,** named in honor of the discoverer of streptomycin, has been established by Rhone-Poulenc, French antibiotic manufacturers, with Jacques Trefouel, director of the Institut Pasteur, as chairman. Four other French investigators, representing different universities, are also members. Grants range from 100,000 to 500,000 francs. In addition, the foundation sends a young French microbiologist to Rutgers University for a year's training and supports in France the work of a Rutgers student. The exchange students this year are Curtis Williams, of the Rutgers Department of Physiology, who is working at the Institut Pasteur, and Pierre Villemin.

Recent Deaths

Thomas N. Adlam (—), heating engineer, West Orange, N. J., Oct. 22; **Suda L. Bane** (66), archivist, Palo Alto, Calif., Nov. 18; **Richmond J. Beck** (—), neuropsychiatrist, New York, Nov. 11; **Paul B. Breneman** (81), mechanical engineer, State College, Pa., Oct. 31; **Percy D. Brewster** (—), motion picture engineer, East Orange, N. J., Oct. 27; **Charles A. Buerk** (67), of Buffalo, N. Y., chemist, Chicago, Nov. 12; **Joseph Celarek** (66), bacteriologist and serologist, New York, Nov. 5; **John A. Church** (67), mining engineer, Washington, D. C., Nov. 10; **Wat T. Cluverius** (77), president, Worcester Polytechnic Institute, New Haven, Conn., Oct. 28; **Barnett Cohen** (61), physiological chemist, Baltimore, Oct. 21; **John B. Congdon** (76), of Albany, N. Y., surgeon, Rutland, Vt., Nov. 12; **John D. Currence** (53), internist, New York, Oct. 20; **Marcus A. Curry** (74), physician, Morristown, N. J., Nov. 11; **William M. Danner** (89), authority on leprosy, Washington, D. C., Nov. 14; **John K. Desmond** (57), metallurgist, Philadelphia, Oct. 27.

Middleton S. Elliott (80), physician, West Los Angeles, Oct. 29; **Armin Elsaesser** (77), goiter specialist, Youngstown, Ohio, Oct. 29; **Gustavus J. Esselen** (64), chemist, Swampscott, Mass., Oct. 22; **C. B. Fawcett** (69), geographer, London, Sept. 21; **Ernest Flammer** (73), physicist, Palo Alto, Calif., Nov. 9; **G. Raymond Fox** (49), of East Providence, physician, Pawtucket, R. I., Oct. 25; **William B. Fox** (37), botanist, Raleigh, N. C., Nov. 13; **José Galli** (—), economist, mathematician, physicist, and astronomer, Buenos Aires, Nov. 6; **Samuel E. Getty** (86), surgeon, Yonkers, N. Y., Nov. 13; **W. King Gillies** (77), educator, Edinburgh, Nov. 15; **Goodlatte B. Gilmore** (59), ophthalmologist, otologist, and laryngologist, New York, Nov. 19; **Arthur S. Gist** (69), educator, Piedmont, Calif., Oct. 26; **Joseph H. Globus** (66), neuropathologist, neuroanatomist, and neurologist, New York, Nov. 20; **Gaylord W. Graves** (68), pediatrician, New York, Nov. 8.

Franklin Harris (57), surgeon, Palo Alto, Calif., Nov. 13; **Halvor O. Hem** (89), mechanical engineer, Toledo, Ohio, Nov. 11; **Harold A. Innis** (58), political economist, Toronto, Nov. 8; **Philip C. Jeans** (69), of Iowa City, pediatrician, Panama, Oct. 22; **Alexander H. Jeffords** (73), industrial engineer, Cleveland, Nov. 10; **Joseph J. Kelsey, Sr.** (63), of Clinton, Conn., engineer, Middletown, Conn., Nov. 10; **Dexter S. Kimball** (87), industrial engineer, Ithaca, N. Y., Nov. 1; **Vladimir Kistyakovsky** (88), chemist, Moscow, Oct. 24; **Zora Klain** (68), educator, New Brunswick, N. J., Nov. 6; **John F. Lane** (36), chemist, New Brunswick, N. J., Oct. 17; **Aurel G. Lavoie** (45), of Springfield, Mass., surgeon, Boston, Oct. 26; **Robert B. Lawson** (77), professor of medicine, Chapel Hill, N. C., Oct. 28; **William E. Leighton** (80), surgeon, St. Louis, Nov. 9; **Charles G. Ligh** (—), electrical engineer, New York, Nov. 2; **Henry D. Lloyd** (74), of Little Compton, R. I., dermatologist, Boston, Nov. 3; **George V. Lomonossoff** (76), electrical engineer, Montreal, Nov. 19; **John K. Love** (84), ophthalmic surgeon, High Bridge, N. J., Oct. 31; **Llewellyn V. Luddy** (77), mechanical engineer, Lafayette, Ind., Nov. 8.

Donald MacDonald 2d (72), civil engineer, Claremont, Calif., Nov. 3; **Lachlan Macleay** (74), flood control expert, St. Louis, Nov. 1; **Edward L. Mack** (62), metallurgical engineer, New York, Nov. 6; **Hans Merensky** (81), geologist, Diuwelskloof, S. A., Oct. 21; **Hugh K. Milliken** (74), of New York and Lyme, Conn., conchologist, Amityville, N. Y., Nov. 7; **Edward L. Miloslavich** (67), pathologist, St. Louis, Nov. 11; **Morton A. Nordgaard** (70), mathematician, East Orange, N. J., Oct. 18; **John M. Pearson** (48), physicist, Swarthmore, Pa., Nov. 16; **Jesus T. Pinero** (55), agriculturist and engineer, Canovanas, P. R., Nov. 19; **Franklin P. Pyles** (70), of Rio de Janeiro, surgeon, New York, Nov. 18.

Maurice Rosenberg (78), gynecologist, New York, Nov. 9; **Emil Schaeffer** (64), civil engineer, Elizabeth, N. J., Nov. 17; **Edward A. Schuch** (49), cartographer, Feasterville, Pa., Nov. 11; **Arnold W. Shilanse** (28), of Wernersville, Pa., psychologist, Washington, D. C., Oct. 21; **Constantine K. Smoley** (83), civil engineer and educator, New York, Oct. 22; **George F. A. Spencer** (95), physician, Ware, Mass., Nov. 17; **John L. Stenquist** (67), educator, Baltimore, Nov. 8; **Daniel B. Street** (77), physician, Jersey City, N. J., Oct. 22; **Louis E. Strittmatter** (58), internist, Philadelphia, Oct. 31; **Samuel H. Thompson** (76), educator, Washington, D. C., Oct. 27; **Selah S. Tomkins** (57), chemical engineer, Bronxville, N. Y., Oct. 29; **William Randolph Walton** (79), entomologist, Washington, D. C., Oct. 20; **Warren G. Waterman** (80), botanist, Frankfort, Mich., Nov. 16; **Gertraud Werner** (40), psychiatrist and psychoanalyst, New York, Oct. 31; **Julian L. Woodward** (52), sociologist, New York, Nov. 4.

Technical Papers

Brain Waves and Unit Discharge in Cerebral Cortex

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In a previous communication in this journal (*1*) on "Charting the Sea of Brain Waves," one of the basic questions that was posed without satisfactory reply was the nature of the relationship which might exist between the slow rhythmic electrical potential oscillations that are recorded from the surface of the cerebral cortex and the action potentials of individual cortical cells. Are the slow waves of 50–100 or more msec in duration merely the smoothed envelope of hundreds or thousands of brief spikes discharging in clusters of imperfect synchrony, or do they represent an electrical phenomenon of a different order? How are the potential rhythms of the cortex that have been studied so extensively in electroencephalography related to actual discharge of individual nerve cells?

During the past year we have made a renewed attack on this problem by the use of glass micropipette electrodes, the inside diameter of which measured 1–3 μ, coupled through a cathode follower stage to a two- or three-channel amplifier oscilloscope apparatus, in order to record isolated spikes from single cortical neurons simultaneously with the slow potential oscillations. The technique was similar to that recently reported by Cragg (*2*), Amassian (*3*), and Thomas (*4*).

Cats under fairly deep Nembutal anesthesia were used. The electrical rhythms of 8–10/sec waves recorded from the surface of the cortex were found to be of practically the same form when recorded with the microelectrode as they were from gross surface electrodes on adjacent cortex. The microelectrode was then inserted into the depths of the cortex with a micromanipulator searching for the unit spike potentials which might form the elementary discharge underlying the slow waves. They were not found.

Only occasional cortical cells discharged for a time in response to the injury of penetration by the microelectrode, but prolonged searching throughout all layers of the cortex failed to pick up individual spikes bearing any relationship to the slow rhythms, and often no spikes at all could be detected in spite of continuous "spontaneous" slow waves. Then it was found that at certain depths in sensory cortex a few isolated spikes regularly appeared in response to tactile stimulation of the cat's paw, so that the microelectrodes were capable of recording action potentials from single nerve cells, but such potentials were not apparent at all or appeared only sporadically, with no relationship to the bursts of rhythmic slow waves in the absence of sensory stimuli. We then suspected the anesthesia.

When local, instead of general, anesthesia was used the picture was completely altered. Active unit spike discharges (Fig. 1) were found continuously in sensory cortex even though slow potential rhythms were less prominent. These spikes were of very short duration, measuring only 0.6–0.8 msec, and varied between 300 and 5000 μv in amplitude, usually negative in electrical sign at the tip of the microelectrode. The smaller ones appeared in the more superficial cortical layers, between 300 and 800 μ from the surface (Fig. 1 *A*), whereas the larger ones appeared deeper, between 1200 and 1800 μ (Fig. 1 *B*). In the upper layer, bursts of spikes frequently appeared on the rising phase or at the peak of each slow wave, but at times they fired off independently, without any apparent temporal relationship to the slow waves.

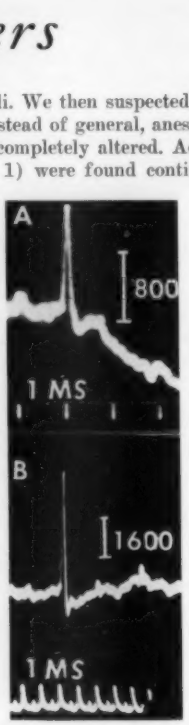

FIG. 1. Action potentials from single cortical cells in the post-sigmoid gyrus of the cat recorded by means of glass microelectrodes of 1 μ or less in diameter and recorded with a condenser-coupled amplifier oscilloscope apparatus of 0.45 sec time constant. Deflection up is electronegative at the electrode tip with reference to a diffuse lead attached to the head holder around the base of the skull. In *A* is shown a unit spike obtained from a depth of 700 μ from the surface, and in *B* is shown the larger spikes obtained at a depth of 1.8 mm from the surface, where there are larger cortical cells.

The constant voltage of these unitary spikes upon repeated discharge and their precise localization (they disappear upon movement of the electrode tip by as little as 50 μ) indicate that they represent action potentials from discharge of single cortical cells. Since they were electronegative in sign, they must have been recorded from just outside the cell membrane. Occasional high-voltage positive spikes were recorded for

brief periods of time when the electrode tip was presumably within a cell body. These were associated with injury discharge and eventual death of the cell and have not persisted long enough for study. It was found that unitary spikes of this type could be recorded only with the smaller microelectrodes, preferably of 1 μ or less. Multiple units of different amplitude were obtained with larger electrodes.

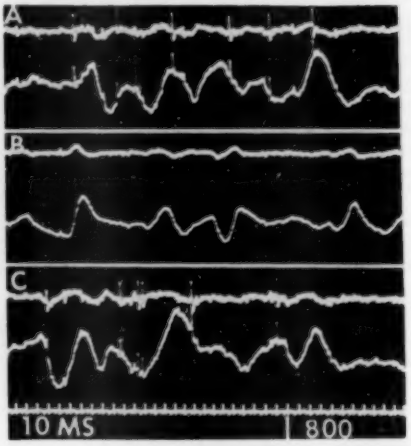

FIG. 2. Unitary spikes and slow waves recorded with a microelectrode connected to 2 amplifier oscilloscope systems for simultaneous recording with a short and a long time constant. The slow waves do not appear, therefore, in the upper tracing in each sample. Records taken at a depth of 1800 μ. *A*, a burst of slow waves and spikes in the animal without general anesthesia; *B*, taken from the same point 8 min following the intravenous administration of 50 mg Nembutal; *C*, taken 1 hr later, when the animal had recovered somewhat from the anesthesia.

Slight anoxia or Nembutal anesthesia would readily abolish the spike discharges, leaving the bursts of slow waves relatively unaffected (Fig. 2), the spikes returning with oxygen administration or by the administration of picrotoxin to counteract the effect of Nembutal. When the spikes disappeared with hypoxia or anesthesia, careful search was made through the cortex in several places in the attempt to find other units that might account for the slow waves, but only an odd sporadic unit was found. It appeared that unit discharge in the cortex had been readily suppressed with slight hypoxia or anesthesia without having much effect upon the rhythmic slow waves.

Higher voltage slow waves caused by applying strychnine or eserine and acetylcholine to the cortex were more consistently related to bursts of rapid spikes during the rising phase or negative peak of the slow wave, although even then they sometimes continued much longer at a frequency unrelated to the slow waves.

These results would seem to prove that the brain waves commonly used by the electroencephalographer as an index of cortical activity may, under certain circumstances, bear little relationship to the active discharge of individual cortical cells, at least of the type from which records can be obtained with microelectrodes. Certainly there is no support for the supposition that the slow waves result from envelopes of spike discharge.

There is also no support for the notion that the "spontaneous" rhythms of the brain are due to nerve impulses circulating in reverberating closed chains of self-re-exciting units, since the slow waves continue when unit discharge (at least as recorded with microelectrodes) is suppressed by hypoxia or anesthesia. In the depths of the cortex one may find extremely active discharge of neurons, or they may be remarkably silent, with very little reflection of these vastly different conditions upon the brain wave record obtained from the cortical surface.

Brain waves do seem to be phenomena of a different order. The most plausible hypothesis is that they represent synchronized oscillations in membrane potentials, possibly involving small interneurons and dendrites in the cortical matrix, oscillations which would have a definite effect upon neuronal excitability, but not dependent upon neuronal discharge. They would thus be classed with the so-called "synaptic" or soma potentials of the spinal cord, which are also obtained from anterior horn cells after the discharge of these cells has been suppressed by barbiturate anesthesia (*5*). Their oscillatory character is of particular interest, since it does not seem to depend upon repetitive discharge of the larger cortical cells of the type whose activity was recorded with the microelectrodes used in these studies. They may still be related to impulses circulating in the fine dendritic network of the cortex, whose unitary activity may not appear with the techniques here employed.

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Influence of Amino Acids upon Incidence of Tumors in *Tu*[50] Stock of *D. melanogaster*

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In a recent report Mittler (*1*) has shown that nutrition of *Drosophila melanogaster* when restricted to certain yeasts alters the penetrance of *tu*[50], a second chromosome recessive mutation located near 90 that produces melanotic growths in the abdomen. Other workers, Tannenbaum (*2*) and Herskowitz and Bur-

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dette (*3*), have found that nutrition influences tumor incidence. In general, poor nutrition or low calorie intake reduces the incidence of tumors. What, then, are the important nutritional factors that play a leading role in tumor production? In an attempt to solve this problem, the diet of Drosophila was rigorously controlled by employing a minimal diet that contains no vitamins or amino acids (Table 1), a diet which differs from the original one employed by Mittler (*1*) in that $NaNH_4HPO_4$ is used for the nitrogen source instead of $(NH_4)_2SO_4$. This medium is inoculated with *Hansenula anomala, H. saturnus,* or *Debaromyces globosus,* yeasts that can grow in the vitamin- and amino acid-free medium. Thus, the nourishment of the larvae was restricted to the yeast employed. A pair of flies was placed in small vials containing about 10 ml of medium to prevent overcrowding and to maintain a standard of comparison.

TABLE 1

MINIMAL MEDIUM
(VITAMIN- AND AMINO ACID-FREE)

Agar	15 (g)
$C_6H_{12}O_6$	10
K_2HPO_4	1
$NaNH_4HPO_4$	2
$CaCl_2$	0.25
$MnSO_4$	0.25
$MgSO_4$	0.25
$FeSO_4$	0.25
H_2O	1000 ml

Amino acids (1 g/1000 ml) were added to the minimal medium, and the incidence of tumors in adult flies was recorded. The results are presented in Table 2. The control experiments were those in which the highly inbred tu^{50j} were reared on minimal medium plus a yeast. The incidence of tumors is much higher when the flies are reared on the highly complex cornmeal-molasses mixture, which evidently contains a more complete diet, and this agrees with the reports in which tumor incidence is high if the nutrition is good. Excess amounts of tryptophane, lysine, and asparagine were found to increase the tumor incidence. Cystine, alanine, phenylalanine, and leucine decrease the penetrance of tu^{50j}. Tyrosine, glutamic acid, arginine, norleucine, histidine, methionine, and threonine have no apparent effect upon the tumor formation.

The role that tryptophane plays in tumor formation is not known; however, 1.4% of tryptophane added to the diet of white rats increased the occurrence of diethylstilbestrol-induced mammary cancer in rats, whereas 4.3% decreased tumor formation (*4*). One would expect that phenylalanine and tyrosine, which can be converted to melanin, would play a role in melanotic growths, but this is not the case in tu^{50j}. Excess amounts of some amino acids have been found to inhibit growth (*5, 6*), and this may explain the lowering of tumor incidence by cystine, alanine, phenylalanine, and leucine.

Phenylalanine (*6*) and arginine (*7*) were found to increase tumor incidence in the fat body of *D. melanogaster*; however, this is a different tumor than tu^{50j}. There is no apparent relationship (or if it does exist it is not known) between those amino acids that increase or decrease tumor incidence. In the case of tumor production in tu^{50j} stock, low caloric intake does reduce the tumor incidence, but not if large amounts of tryptophane, lysine, or asparagine are present, for more tumors are produced than when the flies are reared on a cornmeal-molasses medium enriched with dry yeast. Other nutritional substances

TABLE 2

PENETRANCE OF tu^{50j} WHEN REARED ON VARIOUS MEDIA

		Yeast Inoculants					
		Hansenula anomala		*Hansenula saturnus*		*Debaromyces globosus*	
		Percentage tu	No. flies	Percentage tu	No. flies	Percentage tu	No. flies
Cornmeal-molasses medium		9.2	1380	6.7	1053	6.3	1113
Minimal medium (Mm)		5.2	1259	3.8	1392	3.3	1302
Mm ± 1 g/1000 ml of	L cystine	1.5	1264	2.4	1251	1.1	1091
	DL alanine	2.7	1411	1.3	1233	3.1	1129
	L tryptophane	8.3	1447	7.4	1268	15.7	1338
	L tyrosine	3.7	1351	3.3	1182	1.5	1132
	Glutamic acid	4.3	1301	4.6	1239	4.3	1209
	L arginine	6.9	1163	5.8	1018	5.2	1289
	L lysine	14.6	1436	15.2	1117	11.1	1262
	DL phenylalanine	1.6	1184	2.1	1143	1.8	1222
	DL norleucine	3.9	1281	4.6	1194	4.1	1172
	L asparagine	12.1	1569	12.6	1268	7.7	1431
	Histidine	4.7	1237	5.2	1211	4.6	1214
	DL methionine	4.2	1119	4.6	1261	4.5	1264
	DL leucine	2.1	1189	1.6	1314	1.4	1193
	DL threonine	5.6	1232	4.9	1163	4.8	1228

besides amino acids are being investigated, for they may play an important role in tumor formation.

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Manuscript received June 9, 1952.

The Einthoven Triangle: An Observation Regarding the Validity of the Originally Proposed Triangular Representation of the Human Body[1]

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Divisions of Medicine and Physiology, University of Tennessee, Memphis

The Einthoven triangle, either by direct statement or implication, is usually treated as an equilateral triangular frame of reference inscribed within a homogeneous volume conductor in the form of (*a*) a plane circular slab or (*b*) a sphere (*1*). In some analyses the frame of reference is considered to be located within a homogeneous volume conductor of infinite dimensions (*1*). The potential difference between any two apices of the triangle may be regarded as the projection of an electrical vector, the so-called manifest potential, on a line joining the two apices. It may be shown that when the source of potentials in the volume conductor is an electric doublet situated in the plane of the frame of reference at its center, the manifest potential and the axis of the doublet are codirectional. This is of some importance, since the more nearly the human body approximates the conditions of idealization, the more nearly will manifest potentials, plotted from electrocardiographic potentials or recorded by means of the vectorcardiograph, represent *true* electrical vectors of the heart.

In contradistinction to the electrical models described above, the idealization originally proposed by Einthoven (*2*) consists of a thin slab of homogeneous volume conductor limited by an equilateral triangular boundary. The heart is represented by a centrally located doublet. Whether or not such a model is superior to the more commonly employed forms, it is of interest to ascertain by rigorous analytic methods whether the manifest potential calculated from the apex potentials of the Einthoven model also indicates accurately the direction of the axis of the doublet. We have been able to demonstrate both theoretically and experimentally that such an identity of orientation does exist.

[1] This work was supported in part by a grant from the Memphis Heart Association and a Cardiovascular Teaching Grant, National Heart Institute, U. S. Public Health Service.

The theoretical analysis was accomplished by converting the well-known case of potential distribution due to a centric doublet within a circle, by means of a Schwarz-Christoffel transformation, into the obscure situation of a centric doublet within an equilateral triangle. The circular case (Fig. 1) is that of a circle

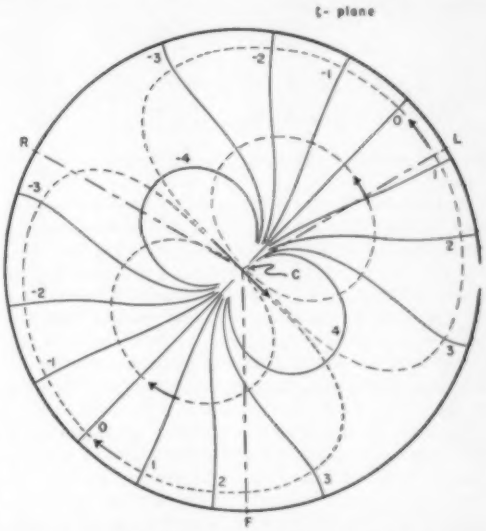

FIG. 1. Centric doublet in a circular, electrically homogeneous slab. Solid curves are isopotential lines; dashed curves are streamlines. Plotted on the basis of $V + iS = Mei^{\alpha}(1/\zeta + \zeta/R^2)$ where V is the potential function, S is the streamline function, M is the "strength" of the doublet, and α is the direction of its axis, ζ is a complex number representing any point in the plane, and R is the radius of the circle. In this figure $\alpha = -45°$. (The equation may be expressed in polar coordinates (r, θ) as a pair of conjugate functions, $V = M(1/r + r/R^2)\cos(\theta - \alpha)$ and $S = M(r/R^2 - 1/r)\sin(\theta - \alpha)$. These functions satisfy the Laplace equation $\nabla^2 V = \nabla^2 S = 0$. The boundary condition, $\delta V/\delta n = 0$, where n is the unit normal at the boundary, is also satisfied. These properties are not altered by the Schwarz-Christoffel transformation described in the text [*3*]).

of unit radius in the complex ζ-plane with three circumferential points equidistant from each other, $L(\sqrt{3}/2, i/2)$, $R(\sqrt{3}/2, i/2)$, and $F(0, -i)$. By substitution in an appropriate formula (*3*), a mapping function is determined which transforms the circle into an equilateral triangle in the complex w-plane, the coordinates of L, R, and F remaining unchanged. The mapping function is defined by the relation

$$dw = K(\zeta^3 - i)^{-\frac{2}{3}}\, d\zeta \qquad (1)$$

where K is a complex constant arbitrarily chosen so that the points L, R, and F will not be rotated by the transformation, or the distance between them altered, and $i = \sqrt{-1}$. Eq (1) can be solved for w by a binomial expansion of the radical expression followed by term-by-term integration. However, the desired information can be obtained without the necessity of resorting to such lengthy manipulations: The radii CL, CR, and CF can be expressed as

$$\left.\begin{aligned} CL&: \zeta = e^{i\frac{\pi}{6}}\lambda \\ CR&: \zeta = e^{i\frac{5\pi}{6}}\lambda \\ CF&: \zeta = e^{i\frac{3\pi}{2}}\lambda \end{aligned}\right\} \qquad (2)$$

where e = the base of natural logarithms and λ is a real parametric variable equal to $|\zeta|$. Substitution of Eq (2) in Eq (1) yields

$$\left.\begin{aligned} CL&: dw = |K|(\lambda^3-1)^{-\frac{2}{3}}\, e^{i\frac{\pi}{6}}\, d\lambda \\ CR&: dw = |K|(\lambda^3-1)^{-\frac{2}{3}}\, e^{i\frac{5\pi}{6}}\, d\lambda \\ CF&: dw = |K|(\lambda^3-1)^{-\frac{2}{3}}\, e^{i\frac{3\pi}{2}}\, d\lambda \end{aligned}\right\} \qquad (3)$$

the real value of the radical being intended in each case.

Certain conclusions are warranted from an inspection of Eq (3): (*a*) the radii in question remain rectilinear after the transformation, (*b*) the 120° angular separation between them is not altered by the transformation, and (*c*) the transformed radii are all of equal length. Therefore we may conclude that the point *C* remains centric in the triangle and that the transformation does not alter the angular relation of any line, as it passes through the center, with respect to the points *L*, *R*, and *F*. Since Schwarzian transformations do not alter the topology of isopotential distributions, and the present transformation in particular does not translocate the electric doublet or rotate its axis, it is evident that the manifest potential calculated from the potentials at the apices of the triangle will have the same direction as the axis of the doublet.

The transformation was demonstrated experimentally by preparing an equilateral triangular model 32.5 cm on a side (Fig. 2) from a sheet of conducting material of intermediate resistivity.[2] A centric doublet consisting of two circular poles 2.5 mm in diameter and separated by a distance of 15 mm between centers was drawn on the model with silver ink. The axis of the doublet was inclined at 45° to the horizontal axis of the model. The poles were energized with an alternating current of approximately 125 c/sec. Isopotential lines were mapped out with an exploring electrode by a null technique in which the model constituted two arms of an impedance bridge. A high sensitivity vacuum tube voltmeter was employed as an indicating device. Since no significant amount of phase shift occurred, the mapping procedure was accomplished with considerable precision.

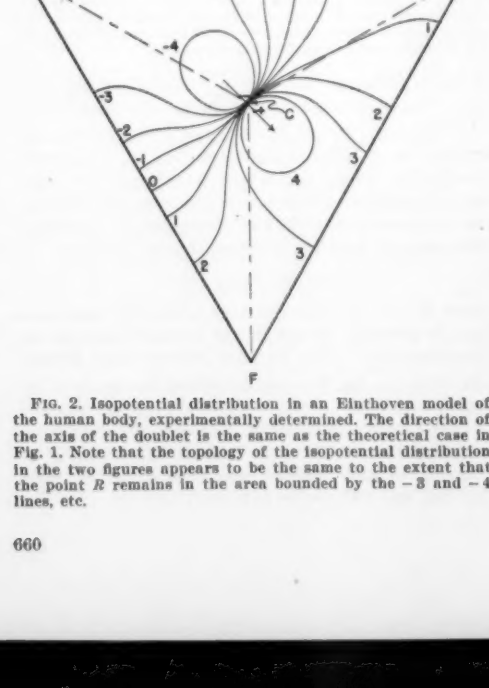

FIG. 2. Isopotential distribution in an Einthoven model of the human body, experimentally determined. The direction of the axis of the doublet is the same as the theoretical case in Fig. 1. Note that the topology of the isopotential distribution in the two figures appears to be the same to the extent that the point *R* remains in the area bounded by the −3 and −4 lines, etc.

The relative potentials at the apices of the model were measured to three significant figures. The manifest potential calculated from these values was directed 44.9° clockwise to the horizontal axis. Because the deviation between this value and the anticipated value of 45° was so small, the experiment appeared to confirm the theory that in the Einthoven model the manifest potential accurately indicates the direction of the axis of the doublet.

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[2] Type 1 Teledeltos paper, General Electric Company.

Surface Activity of Naturally Occurring Emulsifiers

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Recently the addition of emulsifiers or other surface-active agents to foods has led to a discussion of the possible effects of surface activity on normal digestive processes. Before the effects of added emulsifiers can be properly assessed it is necessary to know the level of surface activity resulting from the emulsifiers naturally present. The surface activity of an emulsifier[1] is measured by the change in the tension at an oil-water phase boundary as the concentration of that emulsifier is changed. As far as is known, no systematic study has been made of the boundary tension relationships in systems resembling those appearing during the digestion of fats. In particular, no study has been made of the effects of monoglycerides, bile salts, or fatty acids on oil-water boundary tensions in such systems. Research in this latter field has been started in these laboratories, and the first results of the study are reported here.

[1] The surface activity of any material is measured by the extent to which it is adsorbed at a phase boundary. Highly surface-active materials are strongly adsorbed.

TABLE 1

COMPARISON OF THE SURFACE ACTIVITY OF NATURAL EMULSIFIERS WITH VARIOUS SYNTHETIC SURFACTANTS AT OIL-WATER INTERFACES

Surfactant	Type	Conc wt % external phase	Soluble in oil or water	Interfacial tension	
				1 min (dynes cm^{-1})	20 min (dynes cm^{-1})
Doubly distilled water				24.5	23.6
1-Monopalmitin	Nonionic	1.000	Oil	10.3	10.0
"	"	0.500	"	17.7	16.0
2-Monopalmitin	"	1.000	"	9.9	9.3
"	"	0.500	"	15.8	15.9
1-Monoolein	"	1.000	"	11.0	10.3
"	"	0.500	"	18.6	17.2
Bacto bile salts	Anionic	.500	Water	9.2	6.7
" " "	"	.250	"	12.7	11.0
Sodium cholate	"	.500	"	5.6	4.6
" "	"	.250	"	9.4	8.4
Sodium glycocholate	"	.500	"	9.4	6.7
" "	"	.250	"	10.7	8.7
Sodium laurate	"	.500	"	3.6	1.8
" "	"	.250	"	7.5	6.6
" "	"	.100	"	13.6	12.4
Sodium alkyl sulfate	"	.100	"	3.2	2.1
" " "	"	.025	"	9.9	7.7
" " "	"	.010	"	12.9	10.3
Sodium alkyl benzene sulfonate	"	.100	"	3.9	2.9
" " " "	"	.025	"	7.2	4.6
" " " "	"	0.010	"	9.9	7.0
Dimethylbenzyl alkyl ammonium chloride	Cationic	> 0.025	"	< 0.5	< 0.5
" " " "	"	.025	"	5.7	1.1
" " " "	"	.010	"	8.9	3.5

A method for the measurement of the boundary tension of any system containing surfactants must meet two rigid qualifications: (1) the measurement must be independent of the contact angle between the solution and the measuring device, and (2) sufficient time must be allowed for the diffusion of the surfactant, in equilibrium concentration, to the boundary layer at the freshly formed interfaces. Neither tensiometric nor capillary rise techniques meet these qualifications for oil-water boundary tension measurement in the presence of surfactants.[2] Either the drop-weight method (*2*) or the pendent-drop method (*3*) as modified (*4*) are satisfactory in such systems. In the studies reported here, the drop-weight method for boundary tension measurement has been used primarily. The validity of the results has been checked on several representative systems by measurements with the pendent-drop method. The two methods agreed.

It is instructive to compare the relative surface activity of several different types of surfactants at an oil-water boundary. Data are listed in Table 1 for the interfacial tensions at a cotton seed oil/water interface in the presence of the several surfactants. Double-distilled water, surface tension of 69.5 dynes cm^{-1} at 37° C, was used to make up the aqueous phase. A refined bleached cottonseed oil (CSO), IV = 116, AV = 0.5, was used as the oily phase. All measurements were made at body temperature (37.0° C).

All these surfactants are water-soluble, with the exception of the monoglycerides. The concentration listed in Table 1 refers to the concentration of surfactant in the phase surrounding the forming drop. To insure that concentration changes that are due to adsorption at the drop surface and to partial solubility in the drop-forming phase were minimized, the surfactant solution was used always as the phase surrounding the drop.[3]

These surfactants and emulsifiers at concentrations below 0.5% are grouped into three levels of surface activity. The synthetic materials commonly used as wetting agents, such as the alkylbenzene sulfonates, the alkyl sulfates, or the dimethylbenzyl alkyl ammonium chlorides, are by far the most effective surfactants in the water/oil system. Of intermediate activity are the bile salts and sodium laurate; the monoglycerides, the two monopalmitins, and monoolein compose the third and least surface-active group of the materials studied. It should be emphasized that, of the materials listed in Table 1, monoglycerides are the least surface-active. For example, mixed bile salts, or sodium cholate, or sodium glycocholate are far more effective as surfactants. In addition, it has been established that bile salts form a complex with fatty acids (*5*). Such a complex would be expected to show even greater surface activity at an oil-water boundary than do the bile salts alone.

[2] A recently published work (*1*) showed the capillary rise method to be completely unreliable for interfacial tension measurements in the presence of surfactants.

[3] The drop of the aqueous phase was run into the oil solution of monoolein, whereas the oil drop was run into water solutions of the other surfactants. In an equilibrated system, the boundary tension is independent of the manner in which the drop is formed.

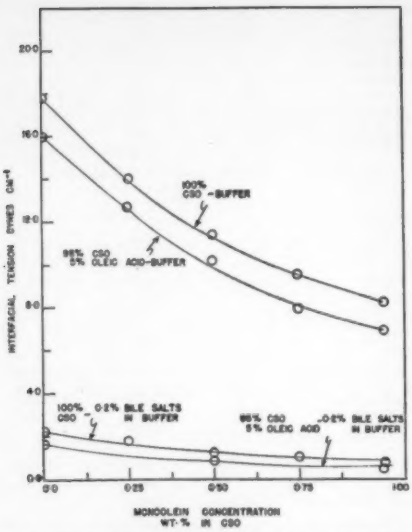

FIG. 1. Effect of monoolein concentration on boundary tensions in systems of CSO and 95% CSO-5% oleic acid in contact with citrate-phosphate buffers at pH 6.0 with and without an added 0.2% bile salts. All measurements were made at 37° C.

The conditions under which the above measurements were made, with the exception of the temperature, are different from digestive conditions. Most fat digestion takes place in the upper part of the small intestine. To approximate the conditions in this region of the intestine during fat digestion, one must consider the pH and bile salt concentration of the aqueous phase, along with the fatty acid content of the fat. In a normal person, the pH in the duodenum is very nearly 6.0 (*5*) during the digestive process. From the available physiological data (*6, 7*) an estimate within the lower range of the bile salt concentration in this region of the intestine would be about 0.2%. Normally the bile salt level would be much higher than that figure.

Work in these laboratories has established that the fatty acid content of digesting fat ranges up to 30% by weight. For the present studies, a concentration of 5% for the free fatty acid was chosen as the minimum expected under digestive conditions.

In Fig. 1, data are shown for the effect of increasing monoglyceride concentration on the interfacial tension of a mixture simulating what might be found in digesting fat—i.e., fat, fatty acid, monoglyceride, bile salts, and buffer solution. For comparison, data are also shown for the effect of monoglyceride on the boundary tension in systems of CSO, 95% CSO-5% oleic acid, and fatty acid-free CSO in the presence of bile salts. A very low interfacial tension is observed in the two systems containing bile salts.[4] It is evident that bile salts are by far the most effective surfactants in a system simulating digesting fat. It is also evident that increasing the monoglyceride concentration above 0.50% cannot result in any appreciable adsorption of the added emulsifier at the oil-water interface. In the absence of bile salts, monoglyceride is surface-active. At a pH of 6.0, fatty acid is practically inert.

The boundary tension of triglyceride-water systems has been found to be quite sensitive to pH, particularly in the presence of fatty acids (*9–11*). The pH range in the intestinal tract ranges from 5.0 at the pylorus to 8.0 at the ileocecal valve (*12*). Boundary tension data were obtained over this pH range for systems of CSO and 95% CSO-5% oleic acid against a buffer solution and against the buffer solution with 0.2% bile salts added. These data are plotted in Fig. 2.

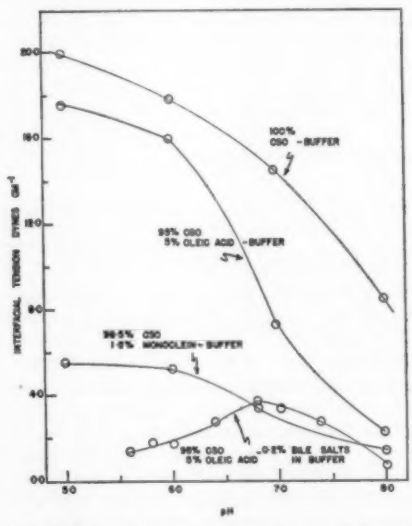

FIG. 2. Effect of pH on oil-water boundary tensions in systems of monoolein, oleic acid, CSO, and bile salts. Citrate-phosphate buffers used and all measurements were made at 37° C.

In general, increasing the pH of the aqueous phase lowers the boundary tension at the oil-water interface. However, with the combination of bile salts and fatty acids an anomaly is observed. The boundary tension rises to a maximum at pH 6.8. Apparently the complex formed between fatty acids and bile salts becomes less surface-active as acid soaps are formed. Notice that at the pH of digesting fat, the combination of bile salts and fatty acid is more effective as a surfactant in CSO than 1.5% of monoglyceride.

A system simulating that occurring during fat digestion is characterized by a very low oil-water boundary tension as a result of the quantities of natural emulsifiers, bile salts, and fatty acids normally present. The low boundary tensions are observed even without monoglycerides, also normally present. In fact, boundary tensions are so low that large quantities of mono-

[4] The low value observed in the system simulating digesting fat is in agreement with the findings of Frazer *et al.* (*8*). These authors state that an interfacial tension on the order of 0.5 dyne cm^{-1} is required for fat absorption.

glyceride could be added without significantly raising the normal levels of surface activity in such systems.

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The Anticonvulsant Activity and Toxicity of Methylparafynol (Dormison®) and Some Other Alcohols[1]

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Although a number of effective drugs are currently available for the control of the human convulsant state (epilepsy), the occurrence of toxic manifestations attributable to these agents stimulates the search for new compounds with low order of toxicity. A good anticonvulsant drug should suppress seizures without hypnosis and, if possible, without untoward effect upon other physiological processes such as hematopoiesis or liver function. Effective use of the barbiturates, hydantoins, or oxazolidines may often be limited by inordinate somnolence, gastrointestinal irritation, personality change, skin eruptions, bone-marrow depression, liver damage, gum hypertrophy, or photophobia.

In October 1951, Margolin, Perlman, Villani, and McGavack (*1*) reported the hypnotic activity of the unsaturated tertiary carbinol, 3-methyl-pentyne-ol-3, which has been used clinically as a soporific under the generic name methylparafynol (Dormison®). This compound, which was shown to have a hypnotic activity in man of about 40% relative to phenobarbital and pentobarbital, was reported to have remarkably low toxicity. Clinical studies revealed no liver, kidney, or bone-marrow damage. No respiratory depression or addiction was observed. Since a number of alcohols, notably isopropyl, have in recent years been studied in our laboratory (*2*), the possible anticonvulsant action of methylparafynol seemed apparent to us. In a preliminary, unpublished study, using the method of Merritt and Putnam (*3*), we found that this pentyne alcohol elevates the cortical threshold for electrically induced seizures in rats. With a dose of 250 mg/kg, the cortical threshold is raised an average of 70.6%. In May 1952, we reported (*4*) the ability of methylparafynol to alter the convulsion pattern of supramaximal stimulation in rats. We found that the duration of anticonvulsant action is in excess of 8 hr, that the action of phenobarbital is potentiated, and that the drug is capable of controlling seizures in human epilepties.

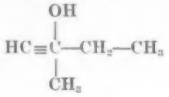
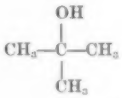
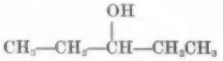
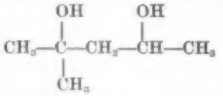
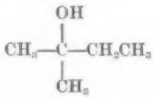
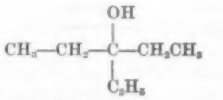
Clinical trials of methyparafynol by the staff of the Stanford Neuropsychiatry Department, however, were suspended after 6 weeks when two of six epileptics under treatment developed strongly positive (3 and 4 plus) cephalin flocculation tests. One week after discontinuation of the alcohol, these tests were negative. A seventh patient, a 13-year-old girl under the care of a private pediatrician, developed a 2 plus cephalin flocculation test during the first 2 months of treatment; but this test reverted to negative under continuing methylparafynol therapy, which was not abandoned since this was the only agent capable of preventing her grand mal seizures. Since, however, clinical laboratory evidence of hepatotoxicity had become apparent in the adult patients, chronic feeding experiments were performed in rats. Five control rats and 10 rats given 0.175% methylparafynol in the drinking water were studied for 4 months. No significant difference was found in growth rate, or in food and water consumption. At the end of each month, a control and a treated animal were sacrificed by decapitation, and the livers were examined histologically by Lelland Rather, of the Stanford Pathology Department. There was no apparent difference in nuclear volume; there was a slight but definite diminution of cytoplasmic basophilia in the hepatic cells of the methylparafynol-fed rats. Loss of cytoplasmic basophilia may under some, but not all, circumstances indicate diminution of ribonucleic acid (*5, 6*). The metabolic and clinical significance of such a change remains to be determined. It might conceivably be associated with changes in the protein production of the liver cell. In order to determine whether the presence of the pentyne alcohol in the blood might produce a "false-positive" cephalin flocculation, this test was performed after the addition of methylparafynol to blood samples from four normal human subjects. Even with excessive concentrations (400 mg/100 ml) of the alcohol, these sera all yielded negative cephalin flocculation tests. It would appear, therefore, that methylparafynol is possibly capable of producing alteration of liver function.

Suspecting that the triple bond in methylparafynol might be responsible for the possible hepatotoxicity, we have undertaken the investigation of a number of saturated secondary and tertiary alcohols. These are listed in Table 1, where their effects are compared with those of methylparafynol, ethanol, and the established

[1] This work was supported, in main, by the Stern Fund for Research in Anticonvulsants and, in part, by Schering Corporation.

[2] We wish to thank Donald Scanlon and Marilyn Enger for their help in the performance of these experiments.

TABLE 1

Compound	Formula	ED_{50}* (mg/kg) oral	TD_{50}† (mg/kg) oral	LD_{50}‡ (gm/kg) oral	PI§	$\frac{LD_{50}}{ED_{50}}$	Duration of action (hr)
Phenobarbital	$C_{12}H_{11}N_2O_3Na$	3.7	28.0	.66	7.6	178	—
3-Methyl-pentyneol-3 (methylparafynol)		50.0	108.0	0.3–0.9 (*1*)	2.2	12	> 8
2-Methyl-2-propanol (tertiary butanol)		59.0	530.0	3.5	9.0	59	> 8
3-Pentanol (diethylcarbinol)		100.0	820.0	2.8	8.2	28	6
2-Methyl-2,4-pentanediol		155.0	650.0	4.7 (*9*)	4.2	30	> 8
2-Methyl-2-butanol (tertiary amyl alcohol)		50.0	160.0	1.0	3.2	20	7
3-Ethyl-3-pentanol (triethyl carbinol)		36.0	72.5	—	2.0	—	—
Ethanol	CH_3CH_2OH	2850.0	6500.0	13.5	2.3	4.7	—

* ED_{50} = Dose which reduces duration of tonic-extensor phase of supramaximal seizures by 50% in rats.
† TD_{50} = Dose which produces ataxia in 50% of rats.
‡ LD_{50} = Dose which is fatal for 50% of rats.
§ PI = TD_{50}/ED_{50}.

anticonvulsant, phenobarbital. The protective index (PI) was calculated by a modification of the "supramaximal" electroshock method of Toman, Swinyard, and Goodman (*7*). Using the apparatus devised by Tainter and associates (*8*), supramaximal convulsions were elicited by the passage of 50 ma (4 times the average threshold) for 1.0 sec through electrodes clipped to the ears of white rats. The ensuing seizures were characterized by a pattern of latent period, tonic-flexor phase, tonic-extensor phase, clonic phase, and stupor. According to Toman, Swinyard, and Goodman, abolition of the tonic-extensor phase represents an anticonvulsant effect. After obtaining control values in seconds for each phase, the animals were starved overnight, given the alcohols by stomach tube, and after careful scrutiny for evidence of ataxia, restimulated 1 hr later. Ten to 20 rats were tested at each dosage level. Plotting on probit paper the percentage decrease in duration of the tonic-extensor phase against the dosage of alcohol results in a straight-line graph, from which can be found the dosage which will reduce the duration of the tonic-extensor phase 50% (ED_{50}). In the same fashion the dose producing ataxia in 50% of the rats (TD_{50}) may be determined. The protective index (PI) is obtained by dividing the TD_{50} by the ED_{50}. When not elsewhere reported, LD_{50} was determined. To determine duration of anticonvulsant action, groups of 5 rats each were tested periodically for reduction of the tonic-extensor phase after medication with the lowest dose affording complete abolition of that component of the supramaximal seizure. In order to avoid aberrant results from restimulation on the same day, a different group of animals was tested at each time interval.

Inspection of the results summarized in Table 1 reveals that two of these alcohols, 2-methyl-2-propanol (PI, 9.0) and 3-pentanol (PI, 8.2), have protective indices greater than that of phenobarbital (PI, 7.6); and two other alcohols, 2-methyl-2,4-pentanediol (PI, 4.2) and 2-methyl-2-butanol (PI, 3.2) are experimentally superior to methylparafynol (PI, 2.2). This, of course, refers to the margin between the effective anticonvulsant dose and the dose producing locomotor incoordination. Consideration of the ratio, LD_{50}/ED_{50}, indicates that the widest margin of safety is present with phenobarbital, followed in decreasing order by 2-methyl-2 propanol, 2-methyl-2,4-pentanediol, 3-pentanol, 2-methyl-2-butanol, and methylparafynol.

Currently the more promising of these alcohols are being subjected to chronic toxicity studies in rats consuming the compounds in their drinking water. The results of this investigation, including blood counts and autopsy, will be reported at a later date. It should be recorded that two long-chain alcohols tested for anticonvulsant activity are not included in the table. Both 2-ethyl-2-hexanol and 3,9-diethyltrideeanol were found to be feeble and erratic anticonvulsants as measured by the supramaximal stimulation test.

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Relationship between Inorganic Phosphorus and Vitamin A in the Rat and Sheep[1]

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Ross and Gallup (*1*) have reported an inverse relationship between blood plasma inorganic phosphorus and plasma carotene in beef cattle fed phosphorus-deficient rations. Kleiber, Goss, and Guilbert (*2*) found a decreased utilization of energy in beef heifers fed rations low in this mineral.

Six experiments have been conducted with rats to study a possible relationship between inorganic phosphorus and carotene and/or vitamin A utilization. Weanling rats of the Sprague-Dawley strain were used in these studies. The rats were first depleted of vitamin A on a ration of cerelose, 68 parts; casein, 15 parts; corn oil, 5 parts; USP salt mixture No. 2, 4 parts; and irradiated dry yeast, 8 parts, by weight.

When the rats became depleted of vitamin A, as characterized by weight loss and eye symptoms, they were divided into uniform groups and placed on the experimental rations. The experimental rations were the same as the depletion ration except that different salt mixtures were used and the amount of irradiated yeast was decreased to 1 part, with a corresponding increase in the amount of cerelose. Carotene in cottonseed oil was added in equal amounts to both the high and low phosphorus rations.

In Expts I, II, and III the salt mixture used in the low phosphorus rations was that of Hubbell, Mendel, and Wakeman (*3*), without the inclusion of potassium phosphate. A corresponding increase was made in the potassium chloride content of this salt mixture. The salt mixture used in the high phosphorus ration in Expt I was USP salt mixture No. 2. In Expt II, potassium phosphate was added to the low phosphorus ration and in Expt III di-calcium phosphate was added to produce the high phosphorus rations. Thus in Expts II and III the total salt content of the high phosphorus ration was greater than that of the low phosphorus ration.

The phosphorus and carotene content of the rations fed, feed consumption, and the liver analyses obtained in the first three experiments are presented in Table 1. The rats were fed the experimental rations *ad lib* for 10 days during Expts I and II and for 15 days during Expt III.

TABLE 1

Feed Consumption and Liver Analyses of Rats Fed Various Levels of Phosphorus and Carotene

	Experiment I		Experiment II		Experiment III	
	Low phosphorus	High phosphorus	Low phosphorus	High phosphorus	Low phosphorus	High phosphorus
Ration composition						
Phosphorus (%)	.15	.53	.18	1.07	.15	.85
Carotene (ppm)	9	9	50	50	6	6
Number rats	12	11	10	13	12	13
Feed consumed per rat						
Total (g)	79.3	72.4	88.5	41.1	58.2	40.0
Carotene (mg)	.71	.65	4.42	2.06	.35	.24
Liver analyses						
Av wt (g)	3.33	3.18	4.31	2.63	3.99	2.41
Vitamin A (IU/g)	26.4	19.3	76.2	59.4	4.3	3.5
Total IU/liver	86.6	60.2	293.1	159.6	16.4	8.3

It will be noted in Table 1 that the rats fed the low phosphorus rations ate more total feed, had larger

[1] Contribution from the North Dakota Agricultural College Experiment Station. Published with the approval of the director of the station.

livers, and stored more vitamin A. The smaller feed consumption of the rats fed the high phosphorus rations in Expts II and III may have been related to the higher salt content of these rations.

at the 1% level. When fed vitamin A the difference was significant at the 5% level.

In addition to the experiments with rats, two groups of 10 sheep each were fed a phosphorus- and carotene-

TABLE 2

AVERAGE LIVER WEIGHTS AND VITAMIN A STORAGE OF RATS FED TWO LEVELS OF PHOSPHORUS WITH CAROTENE OR VITAMIN A

Ration fed	No rats	Av wt liver (g)	Liver vitamin A	
			Per gram (IU)	Total (IU)
Experiment IV—rations fed 14 days				
Control	10	2.34	2.9	7.0
High phosphorus and carotene	9	4.76	8.4	38.6
Low " " "	9	4.15	19.5*	81.5
Experiment V—rations fed 11 days				
Control	10	2.86	1.9	5.6
High phosphorus and carotene	8	4.50	15.7	71.4
Low " " "	7	4.14	32.2*	128.7
High phosphorus and vitamin A	9	4.13	148.9	609.8
Low " " " "	9	4.00	182.0†	734.5
Experiment VI—rations fed 6 days				
Control	5	2.52	4.1	10.4
High phosphorus and carotene	7	3.10	13.5	39.7
Low " " "	8	3.53	19.6*	66.1
High phosphorus and vitamin A	6	3.35	91.7	310.6
Low " " " "	6	3.11	112.7†	346.6

* Differences from high p and carotene significant at 1% level.
† Differences from high p and vitamin A significant at 5% level.

In Expts IV, V, and VI the high and low phosphorus rations contained equal amounts of total salts, and the feed consumption was controlled so that the rats on each ration consumed the same amount. The salt mixture used in the high phosphorus ration was that of Osborne and Mendel (*4*). The same mixture was used in the low phosphorus ration except that the phosphoric acid was replaced with an equivalent amount of citric acid. The low phosphorus ration analyzed 0.13% phosphorus and the high, 0.50%. Carotene was added in equal amounts, 50 ppm, to both rations. The vitamin A rations fed in Expts V and VI contained 62 IU/g.

The number of rats, the length of time they were fed the experimental rations, and the amounts of vitamin A stored in their livers are presented in Table 2. The control rats were killed at the time the other groups were started on their respective rations.

It will be noted in Table 2 that when rats were fed equal amounts of carotene or vitamin A, those fed a phosphorus-deficient ration stored larger amounts of vitamin A. When fed carotene, the difference between the high and low phosphorus rations was significant

deficient ration. The rations consisted of wheat straw, cane molasses, dried beet pulp, and minerals. The wheat straw fed occasionally contained small amounts of carotene. One lot of sheep received steamed bone meal as a phosphorus supplement. After the sheep had been fed for approximately 6 months, the rations were reversed with respect to the phosphorus supplement. They were fed these rations for a total of 18 months.

The sheep were bled at intervals for blood serum inorganic phosphorus and vitamin A determinations. A highly significant negative correlation ($r = -0.39$) was found to exist between these two blood constituents (unpublished data by the authors).

A statistically significant inverse relationship has been found between inorganic phosphorus and carotene and/or vitamin A utilization.

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Comments and Communications

Sulfur in Ether Extracts of Lake Sediments

DURING a study of the carotenoids of mud from Linsley Pond, Conn., a relatively large amount of a crystalline substance was encountered in an ether extract. In order to get a sufficient amount of the material for analysis, 245 g of mud was dried at 75° C for 24 hr and then exhaustively extracted with diethyl ether. The crystals separated when the ether was cooled and concentrated over a stream of nitrogen. The yield of once-recrystallized material was 2.70 g, mp 119°–120° C. The sample was twice recrystallized from ether, with a final yield of 1.54 g of monoclinic crystals, melting point unchanged. A fraction was sent to Carl Tiedcke for analysis. The results were as follows: C: 0.00%, 0.00%; H: 0.00%, 0.00%; mol wt: 35, 28; 33, 32. Subsequent separation of the rhombic form, together with the above data, was sufficient to characterize the material as sulfur. Sulfur formed 1.1% of the dry weight of the mud. Total ether-extractable substances formed 2.1% of the dry weight of the mud, hence more than half the ether extract consisted of elementary sulfur.

The occurrence of sulfur in lake sediments is of interest, since some limnologists have interpreted ether and benzene extracts in terms of lipids only. The behavior of sulfur resembles lipids in that it leaves no ash on ignition, is insoluble in water, and is soluble in such solvents as ether, chloroform, and benzene. Unless supplemented by analysis for sulfur or organic carbon, such extracts will have at least a dual meaning and must be cautiously interpreted. This work forms part of a program supported by National Science Foundation Grant G-14 given to G. Evelyn Hutchinson.

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Use of Propositions in Examinations for the Doctor's Degree

DURING the past seventeen years the final examination for the doctor's degree for students majoring in chemistry at the California Institute of Technology has consisted in part of the oral defense, by the candidate, of a set of propositions prepared by him and submitted to the examiners two weeks before the day of the examination. It is the opinion of members of the staff of the Division of Chemistry and Chemical Engineering, after these years of experience, that the use of propositions contributes significantly to the effectiveness of the examination, as well as to the interest of the examiners.

In 1935 the members of our staff, after participation in several scores of doctor's examinations during the preceding fifteen years, had become bored by them. The thought occurred to me that the system of propositions (*stellingen*) that has been used in examinations for the doctor's degree in the universities of Holland for hundreds of years might be introduced. One of my students, David Harker, agreed to prepare a set of propositions in order that a trial of the proposal might be made. His oral examination for the degree of Doctor of Philosophy in chemistry, with a minor in mathematics, which was carried out with the use of propositions on May 31, 1935, was much more interesting to the examiners, and apparently to the men being examined, than most of the earlier examinations had been. The members of the committee were also of the opinion that it provided a better test of the candidate than was provided by examinations of the sort previously given, in which the candidate was asked questions arbitrarily formulated by members of the examining committee. The decision was accordingly made that all candidates for the doctor's degree in chemistry should thereafter prepare propositions.

Dr. Harker introduced the system at the Johns Hopkins University when he was appointed a member of the staff there, and it is now in use in several other universities, including Princeton, the University of California, the University of Southern California, and Columbia. In some institutions (University of California and Division of the Geological Sciences at the California Institute of Technology) propositions are used in connection with the examination for admission to candidacy for the doctor's degree, rather than in the final examination.

The nature of the system may be indicated by the regulation in the Division of Chemistry and Chemical Engineering of the California Institute of Technology, which reads as follows:

> 5. The final examination will consist in part of the candidate's oral presentation of a brief résumé of his research and its defense against attack, and in part of the defense of a set of propositions prepared by the candidate. The candidate may also expect questions related to his minor subject.
>
> The propositions should be about ten in number, of which about four should relate to the minor subject and to general branches of chemistry, and about six to the branch of chemistry of major interest to the candidate, including his research.
>
> For students in chemical engineering about three propositions should relate to the minor subject, two to chemistry if this is not the minor subject or to mechanical engineering if chemistry is the minor subject, and about five to chemical engineering. The candidate may also include propositions not relating to his major and minor fields.
>
> The propositions, prepared by the candidate himself, should display his originality, breadth of interest, and soundness of training; the candidate will be judged on his selection and formulation of the propositions as well as on his defense of them. It is recommended that the candidate begin the formulation of his set of propositions early in his course of graduate study.
>
> Two copies of the set of propositions in final form must be submitted to the Division of Chemistry and Chemical

Engineering at least two weeks before the date set for the examination. A copy of the set of propositions must be submitted to the Dean of Graduate Studies as a part of each of the two copies of the thesis.

Some idea of the nature of the propositions themselves may be given by the presentation of representative examples. The set of propositions prepared by David Harker in 1935, on short notice, follows:

At the time of his oral examination for the degree of Doctor of Philosophy, David Harker will defend the following Propositions:—

1. Cadmium iodide can crystallize in either the structure proposed by Bozorth (*J.A.C.S.* **44**, 2232 [1922]) or that proposed by Hassel (*Zeit. Krist.* **22**, 333 [1933]).

2. The radial parts of the solutions of Schrödinger's equation for the isotropic three-dimensional harmonic oscillator, separated in spherical coordinates, are given by

$$R_{n,\,l}(x) = Ne^{-\frac{x}{2}} Z^{\frac{l}{2}} \frac{d^{l+1}}{d_Z^{\,l+1}} [H_{n+l+2}(Z^{1/2})]$$

where $z = \frac{4\pi^2 \mu_0 m}{h} r^2$, $n+l$ is always even, and N is a normalizing factor.

3. The series $\sum_{\mathbf{h}} \frac{1}{|\mathbf{h}|^2} \cos\ 2\pi \mathbf{r} \cdot \mathbf{h}$ is convergent if $\mathbf{r} \cdot \mathbf{h}$ is not an integer.

4. The number of spots on a Laue photograph within a given distance of the central image is independent of the orientation of the crystal and proportional to the volume of the primitive unit cell, under a given set of experimental conditions.

5. The use of the "spring-reservoir" in the definition of entropy is to be preferred to use of the Carnot cycle.

6. The anomalous crystal structures of the metals zinc, cadmium, and mercury can be explained on the basis of a tendency toward covalent bond formation.

7. The structure of the tri-iodide ion given by R. C. L. Mooney (*Zeit. Krist.* **90**, 143 [1935]) must be incorrect. This error is probably due to the neglect of the ammonium ions in evaluating the iodine parameters for the crystal NH_4I_3.

8. The behavior of the vapor pressure of hydrofluoric acid from its solutions in benzene can be explained on the basis of association of gaseous hydrofluoric acid to H_6F_6 without the use of the very special assumptions used by J. H. Simons (*Chem. Rev.* **8**, 213 [1931]).

9. A device for indexing oscillation and rotation X-ray photographs of crystals, consisting of a projection of the propagation sphere on a plane, has points of superiority over the method of the Bernal diagram.

10. The proof, given by Bochner (*Vorlesungen uber Fouriersche Integral*) that every fraction that has an absolutely integrable derivative in an interval has limited fluctuations in that interval, is very elegant.

Examples of other propositions that have been given by candidates recently are the following:

I predict that a determination of the temperature coefficient of solubility of benzene in 0.2 *N* aqueous silver nitrate solution would reveal that there is a reversal in the sign of the coefficient somewhere between 10° and 70° C.

The pure L isomer of *sec*-butyl alcohol might be prepared by reduction with Raney aluminum-nickel alloy of L-erythro-3-chloro-2-butanol, which is obtainable from the available compound D-2,3-butanediol.

The measurement of Soret coefficients is notable for the lack of agreement among various observers. It is likely that the disagreement arises from failure to suppress convection currents completely. I propose that thermal diffusion cells be constructed using a porous diaphragm between two thermostated reservoirs. The pores of the diaphragm can be small enough that convection is negligible. The solutions should be circulated within each reservoir.

It is proposed that electrophoretic mobilities calculated by the method of Longsworth and MacInnes are in error, because no correction is applied by these authors for the volume change on the closed side of the cell resulting from the net transference of water due to the difference in hydration of the anions and cations which are transferred.

The Hammick reaction has hitherto been applied to aldehydes and ketones only. I propose attempts to apply it to esters and nitriles, as a new alcohol and ketone synthesis, respectively.

The heterogeneity of sensitized red blood cells toward hemolysis by antisera may be explained on the basis of rapid irreversible random combination of hemolysin with a homogeneous red cell population.

Ethers have been used almost exclusively for the extraction of complex metal acids (for example, $HFeCl_4$) from aqueous solution. It is suggested that benzotrifluoride ($CF_3C_6H_5$), trifluoromethyl-cyclohexane ($CF_3C_6H_{11}$) or other fluorinated compounds be substituted for ethers.

A method for the determination of microquantities of water might be developed by using a modified Karl Fischer reagent and electrolytically generated iodine.

In his book *The Optical Principles of the Diffraction of X-Rays*, R. W. James states that the formula for the total intensity of the X-rays scattered by a molecular liquid, first derived by Menke, can be applied without regard to the partial ordering of adjacent molecules. This does not seem to be correct.

The apparently normal heat of hydrogenation of hydrindene need not be regarded as contradictory to the thesis of Sidgwick and Springall that in this compound the benzene system is considerably perturbed by the Mills-Nixon effect.

The difficult task of indexing the lines on X-ray powder photographs would be considerably easier if the degeneracy of the lines were known. It should be possible to determine the degeneracy in many cases from the density of grains in the powder lines on a photograph taken of a closely ground sample.

The calculation by Penney and Sutherland of the valence angle of ozone is incorrect, and the conclusions which they drew therefrom as to the correct assignment of the fundamental vibration frequencies are not valid.

An interesting program of investigation would be the experimental study of low-temperature transitions in solids, using an automatically regulated adiabatic calorimeter. A design for the regulator is proposed.

The methods used for developing critical habits of thought in undergraduates at the California Institute of Technology can be improved.

The nature of scientific research is now such that a graduate student ordinarily has little opportunity to show his originality. Many fields of research require the use of large and expensive pieces of apparatus, which could not be designed and constructed by a single student. Most research problems require so much effort—extending over two or three years—that a student can tackle only one problem in his work for the doctor's degree, and very often the problem on

which he works has in fact been suggested by the faculty member under whose direction he is carrying on the work. The formulation of a set of propositions provides him with an opportunity for expressing his originality; a proposition may give the result of a small original investigation that the student has carried out, or may be a proposal that an investigation be carried out. The system of propositions in doctor's examinations may have its greatest value in encouraging originality in young scientists and in serving as a test of their originality.

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Isolation of *Salmonella schwarzengrund* from Turkey Poults

IN MARCH 1952, nine-day-old turkey poults from a farm in southern Indiana were submitted to the Diagnostic Laboratory. The poults showed a severe diarrhea and protruding vents. Internally there were no observable lesions except a mild enteritis. The mortality in the group of 13,000 turkeys by weeks was as follows: 217, 327, 117, 93, 28, 14, 14, 14, 12, 14 up to and including the tenth week. These poults had been purchased from a hatchery in Michigan, which had obtained the turkey hatching eggs from breeders in California and Oregon.

A gram-negative organism isolated from the livers of the affected turkeys was identified by R. P. Edwards, of the Enteric Bacteriological Laboratories, of Chamblee, Ga., as *Salmonella schwarzengrund* I, IV, XII: d: 1, 7. Unlike the original of this organism identified by Kauffmann (*1*), the organism isolated in this case did not have XXVII antigenic factor in the O formula. This is believed to be the first isolation on this continent and the second recorded isolation of *Salmonella schwarzengrund.*

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Book Reviews

Chemical Physiology of Endoparasitic Animals. Theodor von Brand. New York: Academic Press, 1952. 339 pp. $7.50.

The publication of this book will come as a welcome addition to the libraries of parasitologists and others who are interested in the more dynamic aspects of the biology of endoparasites. Professor von Brand has undertaken the problems of synthesis and integration of the accumulated information concerning parasite physiology with the authority of one who has seen the growth of this information, from the beginning of the modern period of accurate observation, and has contributed importantly to this growth. Those familiar with his work will recognize the excellent organization and the readable style of writing that have characterized his earlier efforts.

The book is divided into three main sections. The first of these is devoted to discussions of the chemical composition of endoparasites, wherein the author tells of the various organic and inorganic molecules, the vitamins, enzymes, and other structural and functional entities that are to be found within the protoplasmic make-up of many different parasites. The second section is an impressive presentation of the information that has accumulated in the subjects of intermediary metabolism, respiration, and nutrition of many diverse forms of parasitic life. In this section especially, the author has assumed that the reader will have a genuine interest in the context and will not be content to accept without question a superficial account of parasite metabolism. He wisely presents the material in such a way that the student can make a critical analysis of the situation existing in regard to any one of the many aspects of parasite metabolism that have been investigated. Frequent reference is made to the original literature. The final section is devoted to a most interesting account of the physiological aspects of host-parasite relationships in which nutritional, metabolic, and hormonal factors are explored and the subject of chemotherapy is discussed. This section is well done and is noteworthy in that it creates within the reader a true insight into the intricate manner by which parasites and their hosts are physiologically interrelated. Included in this section are the results of some of the recent investigations involving the endocrine glands.

The author has recognized that controversy exists in many areas and has presented his material in such a manner that the reader is encouraged to consult the original literature. To this end he has compiled and included the most complete bibliography that has appeared in the field of experimental parasitology. This extensive citation of literature will be of particular value to the parasitologist who is not too well acquainted with the rapidly expanding work in parasite physiology and also to the student who is endeavoring to build up a bibliography in this field. The author has made frequent use of tables and charts. These are very clear and concise and where possible include the source of the material given. A feature of the book that may be especially helpful to those

just becoming interested in the application of the physiological method to parasitological investigations is the frequent mention of unsolved problems pertinent to the various topics under discussion.

Von Brand has attained the aims that he set forth in his preface and has produced a book that will not only enhance our grasp of the facts related to parasite physiology, but one that may play a large role in interesting young biologists in this vital area of human knowledge. It is unreservedly recommended to those upon whose interests it may touch.

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Physics and Medicine of the Upper Atmosphere: A Study of the Aeropause. Proceedings of a Symposium on the Physics and Medicine of the Upper Atmosphere held at San Antonio, Texas, November 6–9, 1951. Clayton S. White and Otis O. Benson, Jr., Eds. Albuquerque: Univ. New Mexico Press, 1952. (For the Lovelace Foundation for Medical Education and Research.) 611 pp. Illus. $10.00.

This compendium of current knowledge of the upper atmosphere will prove informative and exciting to both scientific and lay readers. It will sharpen the desire of many people to test their ability to foresee the experiences of those who may someday engage in astronautical flights. The book constitutes the proceedings of a symposium on the physics and medicine of the upper atmosphere held at San Antonio, Texas, Nov. 6–9, 1951, sponsored jointly by the Air University School of Aviation Medicine, Randolph Field, Texas, and the Lovelace Foundation for Medical Education and Research, Albuquerque, N. M. The editors are both well-known authorities in the field of aviation medicine: Dr. White is director of research of the Lovelace Foundation and head of a section of aviation medicine in the Lovelace Clinic; Brigadier General Benson (USAF, MC) is commandant of the USAF School of Aviation Medicine. The foreword is by Harry G. Armstrong, USAF surgeon general, under whose guidance the Department of Space Medicine at the School of Aviation Medicine was organized some five years ago.

The volume consists of the contributions of 34 leading scientists, many of whom have devoted years to the study of problems closely related to the exploration of space by manned and by unmanned devices. Scientific foundations for today's thinking and planning in this field have taken form rapidly, and this book will occupy a position of honor—possibly that of the cornerstone of astronautics.

It was only 35 years ago that the Army adjutant general appointed a board of medical officers to study and make recommendations concerning the selection and maintenance of pilots. The board's first action was to set up a research laboratory, which today is represented by the School of Aviation Medicine at Randolph Field. Basic and applied research in aviation physiology, psychology, and medicine has progressed rapidly in the intervening years. In the fall of 1948 the school held its first symposium on space medicine. Under the guidance of John P. Marbarger, director of research in its Aero-Medical and Physical Environment Laboratory, the University of Illinois sponsored a second symposium on this subject in Chicago, March 3, 1950.[1] The four-day symposium represented by the volume under review was held a year and a half following the one in Chicago, several of the same scientists participated, and the total attendance was 400. The rapidity with which creative thinking is progressing in this field is evident from a statement by Dr. White in his introductory chapter: "Without exception, the authors who prepared the material for this volume gained much from the experience of the San Antonio symposium. Many completely rewrote their papers after the meeting, and by far the majority made major revisions in their discussions."

Defining the aeropause as "a functional border region between space and the atmosphere of the earth," the emphasis in the symposium was on working toward the optimum pilot-airplane combination for man's travel beyond the stratosphere. In Chapter 1 basic problems which must be solved to achieve this end are reviewed by a leading engineer—Alfred M. Mayo, of Douglas Aircraft Company; in Chapter 2 these problems are presented by an outstanding specialist in aviation medicine—Hubertus Strughold, now head of the Department of Space Medicine at Randolph Field. Following these two statements, there are 17 chapters, by as many authors, which are devoted to various physical aspects of the upper atmosphere, including biological effects of radiation and of meteorites.

A third section, appearing as Chapter 20, reports a panel on "Methods and Vehicles for Research in the High Atmosphere," under the chairmanship of James A. Van Allen, of the Department of Physics, State University of Iowa. Including the contribution of the chairman, there are 10 subchapters in this division. Finally, under the chairmanship of Paul A. Campbell, director of aero-medical research at Randolph Field, a panel on "Known and Predicted Problems of Human Travel in the Aeropause," comprising 13 papers by as many authors, and presented as Chapter 21, completes the contributed papers. There is an appendix which includes seven conversion tables and 46 halftone plates, many of them full-page. The 27-page index is excellent, covering not only names and subjects but also biographical references.

Children of this and earlier generations have played a game of throwing up sticks and stones and calling out, "Everything that goes up must come down." An even more exciting game is now in prospect, and this book gives the widest range of facts and suggestions on how to play it.

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[1] *Space Medicine, The Human Factor in Flights Beyond the Earth.* J. P. Marbarger, Ed. Urbana: Univ. Illinois Press (1951).

Fundamentals of the Histology of Domestic Animals. Alfred Trautmann and Josef Fiebiger; trans. and rev. from the 8th and 9th German eds. of 1949 by Robert E. Habel and Ernst L. Biberstein. Ithaca, N. Y.: Comstock Pub., Cornell Univ. Press, 1952. 426 pp. Illus. $8.75.

In an evaluation of the English translation of Trautmann-Fiebiger, it is well to keep in mind the history and characteristics of the German text itself. This European work represents an extreme condensation of several very detailed and well-documented German texts on comparative domestic animal histology. At intervals a considerable amount of new material, with many very excellent illustrations and color plates, was added. It is natural that a book condensed to this degree to be used as a school text could not include the extensive bibliographies of the works on which it is based.

The preparation of the English text involved translation primarily, although considerable rearranging, and some substituting, adding of new material, and condensing were done.

Many excellent improvements are seen in the form and arrangement of the contents. For instance, light and boldface type in varying sizes are used to emphasize headings and subheadings. In addition, the various units of subject matter are set apart in chapter form. The use of center headings exclusively for this purpose in the German text was confusing. Readers will welcome the use of a standard type face that is uniformly readable. In the German text the reviewer often found general subject matter in addition to the minute detail buried in fine print.

Numerous excerpts summarizing recent important researches, together with references, have been added. The translation is free enough to avoid cumbersome German sentence structure, yet literal enough to preserve the original thought or meaning. In a trifling number of instances inexact translation and a poor choice of equivalent words were noted, especially in the section on basic tissues. For example, in the discussion of reticular fibers, an addition of the translator states that reticular fibers "branch as collagenous fibers are not supposed to do." In the previous paragraph of the original text and also in the translation it is stated that collagenous fibers do branch, as we well know. In another place the German text states that smooth muscle cells are enveloped in ". . . *Membranellen, die viele feine Reticulinfasern und auch elastische Fasern enthalten.* . . ." This implies that there is a predominance of reticular fibers, which is correct. The English translation reads, ". . . many elastic fibers and reticular fibers . . . ," and as such neutralizes or reverses the emphasis. An example of poor choice of words is seen in the chapter on the female genital organs. It is stated that the "mucosa bears a columnar epithelium whose cells are only temporarily ciliated." The German word in question is *"zeitweise,"* and it is apparent that the English equivalent would more properly be "occasionally" rather than "temporarily."

The reviewer highly recommends this text to those interested in domestic animal micromorphology, since in addition to being the only textbook in the English language in its field, this translation is a very significant achievement in its own right.

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Chemical Engineering Techniques. B. E. Lauer and Russell F. Heckman. New York: Reinhold Pub., 1952. 496 pp. Illus. $6.00.

The volume is characterized by the authors as "a new treatment of the methods used in conducting chemical manufacturing operations," in which they emphasize techniques rather than specific equipment. A well-arranged series of topics, such as "The Assembly of Materials," "The Preparation of Materials for Reaction," "The Production and Distribution of Energy," "Conditions Affecting the Chemical Reaction," "The Separation and Purification of Materials," and "Further Treatment of Products for Sale, Shipment, Storage, or Other Use," is covered in a completely descriptive, brief, and quite elementary manner. Much of the material duplicates that already covered in current works on unit operations and other engineering texts.

The book will probably have greatest use in presenting to nontechnical students or nontechnical personnel in industry the scope and approach to problems of a chemical nature by the chemical engineer. Unfortunately it leaves the reader stranded in that no references are given through which topics of interest might be further pursued. The authors have attempted to cover a tremendous field in a small volume, which leads to the characterization of "less and less about more and more" for this work. The printing, binding, and illustrations are good.

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Ultraviolet Radiation. Lewis R. Koller. New York: Wiley; London: Chapman & Hall, 1952. 270 pp. $6.50.

Dr. Koller's book is a useful summary of much of the literature about ultraviolet radiation and is clearly addressed to the nonspecialist. After a short introductory chapter, it discusses the various artificial and natural sources of ultraviolet radiation, and next deals with its transmission and reflection by a number of substances commonly used in scientific laboratories, as well as some tissues such as human skin, and some materials of industrial importance. The last two chapters deal with miscellaneous applications of ultraviolet radiation and with the means of detecting it, nearly all the space in the last chapter being given to photoelectric devices.

There is a good index, and the book is valuable for reference. It cannot be said to be equally valuable as

a text. The author's haphazard use of photometric units and notation lead him to make statements such as the one on page 91, that "the amount of energy radiated normal to . . . a flat surface" is obtained by dividing by π the total amount of energy radiated by it. What is meant is, of course, that the radiance normal to the surface is $1/\pi$ times the total radiant flux per unit area. This is true only if the surface is a perfect diffuser, a fact not mentioned by Koller. It seems unfortunate that the logical nomenclature adopted by the Optical Society of America and the Illuminating Engineering Society was not followed.

There are a few misprints, the most serious one being in the scale of abscissae of Fig. 8 (*d*) on page 248, which may mislead some users of S-5 phototube cathodes.

The author is at his best when he is in his own field, but this reviewer gets the impression that some sections of the book—for instance, the one on atmospheric ozone—have been written hurriedly. Very little of our information about the distribution of ozone in the atmosphere has been obtained by means of radiosondes and rockets, the only methods mentioned by the author. The book can scarcely be recommended for those completely new to the subject.

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Water. A Study of Its Properties, Its Constitution, Its Circulation on the Earth, and Its Utilization by Man. Cyril S. Fox. New York: Philosophical Library, 1952. 148 pp. Illus. $8.75.

Water, the short but emphatic title of this book, has lately become most important throughout the world. The vast striving everywhere toward greater agricultural and industrial production has stimulated an enormous thirst for water. The most common of fluids has become a strategic material. As the author emphasizes, adequate basic data and soundness of analysis are the key to proper management and development of water resources; therefore, a book that helps to explain the occurrence and distribution of water is to be welcomed.

The first part deals with the properties, occurrence, and circulation of water and includes an account of the water budget of the earth. Although these broad generalizations on the hydrologic cycle are of background interest, an explanation of the physical relations between the various elements of the hydrologic cycle would have been equally helpful and in some ways more practical. For example, the author seems content with the statement that runoff is often taken as one third of the rainfall. This ratio is of course highly variable, and further development of the relationship would have been desirable.

The second part of the book deals with water as a geologic and geochemical agent. Here, again, discussion of the river forms and modern erosion would have been valuable in a book that is geared to the utilization of water—the final part of the book. The author shows the trend toward multiple-purpose developments, drawing most of his examples from the U. S., rightly emphasizing the need for adequate hydrographic data.

This is not a book for the professional worker; the layman might find it informative, although not necessarily an authentic text. There are numerous misstatements of facts, some of which might be charged to poor editing. The word "hydrology," the basic subject of the book, is persistently misspelled. The professional worker in hydrology will be annoyed with unprofessional details and bothered most by the unprofessional units. The author refers to the same physical quantities—even in the same paragraph—in different units, making comprehension of relative values quite troublesome. Volumes are reported in cubic feet, cubic miles, cubic meters, and acre-feet, velocities in inches per second, feet per second and miles per hour. It would have been preferable had the author observed the practice common among hydrologists in English-speaking countries of reporting rates of flow in cubic feet per second, volumes in gallons or acre-feet, and velocities in feet per second. As it is, the publisher might well provide each reader with a slide rule.

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U. S. Geological Survey, Washington, D. C.

Scientific Book Register

Modern Science and Modern Man. Bampton Lectures in America, No. 5; delivered at Columbia University, 1952. James B. Conant. New York: Columbia Univ. Press, 1952. 111 pp. $2.25.

Fatigue and Fracture of Metals. A symposium held at the Massachusetts Institute of Technology, June 19–22, 1950. William M. Murray, Ed. Cambridge, Mass.: Technology Press of MIT; New York: Wiley, 1952. 313 pp. Illus. $6.00.

Synopsis of Pathology. 3rd ed. W. A. D. Anderson. St. Louis: Mosby, 1952. 788 pp. Illus. $8.00.

Resource Conservation: Economics and Policies. S. V. Ciriacy-Wantrup. Berkeley: Univ. California Press, 1952. 395 pp. $6.50.

Wood Chemistry, Vol. 1. 2nd ed. American Chemical Society Monograph Series. Louis E. Wise and Edwin C. Jahn, Eds. New York: Reinhold, 1952. 688 pp. Illus. $15.00.

Dr. Howe and the Forsyth Infirmary. Rollo Walter Brown. Cambridge, Mass.: Harvard Univ. Press, 1952. 188 pp. $3.50.

Textile Chemicals and Auxiliaries. Henry C. Speel, Ed. New York: Reinhold, 1952. 493 pp. Illus. $10.00.

Photoelectric Tubes. 2nd ed. A. Sommer. London: Methuen; New York: Wiley, 1951. 118 pp. Illus. $1.90.

Textbook of Quantitative Inorganic Analysis. 3rd ed. I. M. Kolthoff and E. B. Sandell. New York: Macmillan, 1952. 759 pp. Illus. $6.50.

Science and Method. Repr. Henri Poincaré; trans. by Francis Maitland. New York: Dover, 1952. 288 pp. $2.50; $1.25 paper.

Maleic Anhydride Derivatives: Reactions of the Double Bond. Lawrence H. Flett and William Howlett Gardner. New York: Wiley; London: Chapman & Hall, 1952. 269 pp. $6.50.

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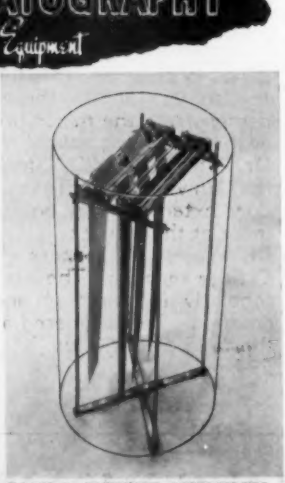

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Publications Received

Annotated Bibliography of Vitamin E. Vol. II, 1950 and 1951. P. L. Harris and W. F. Kujawski, compilers. Rochester, N. Y.: Distillation Products Industries, 1952. Distr. by Natl. Vitamin Foundation, 150 Broadway, N. Y. 7. 106 pp. $2.00.

The Birds of Crater Lake National Park. Donald S. Farner. Lawrence: Univ. Kansas Press, 1952. 187 pp. Illus.

Blueprint for a Red Generation. The Philosophy, Methods, and Practices of Communist Education as Imposed on Captive Hungary. William Juhasz. New York: Mid-European Studies Center of the National Committee for a Free Europe, 1952. 101 pp. 50¢.

Developmental Plant Anatomy. A Workbook for Use in a General Course. Richard A. Popham. Columbus, Ohio: Long's College Book Co., 1952. 361 pp. Illus. (mimeo.)

A Generic Synopsis of the Lizards of the Subfamily Lygosominae. M. T. Mittleman. Smiths. Misc. Coll., Pub. 4096. Washington, D. C.: Smithsonian Institution, 1952. 35 pp.

Great Barrier Reef Expedition, 1928–29. Scientific Reports, Vol. VI, No. 3, ***Madreporaria, Hydrocorallineae, Heliopora and Tubipora.*** Cyril Crossland. London: British Museum (Natural History), 1952. 257 pp. + 56 plates. £3 10s.

Kodak Data Book on Slides. 4th ed. Rochester, N. Y.: Eastman Kodak Company, 1952. 49 pp. Illus. 50¢.

A Laboratory Manual for Elementary Plant Physiology. Victor A. Greulach. Minneapolis: Burgess, 1952. 85 pp. $2.25.

Laboratory Manual for Microbiology. (To accompany *Microbiology with Applications to Nursing.*) Catherine Jones Witton. New York–London: McGraw-Hill, 1952. 76 pp. $2.00.

Let Freedom Ring. The Struggle for a Peaceful World. Dept. of State Pub. 4443, General Foreign Policy Ser. 67. Washington, D. C.: GPO, 1952. 96 pp. Illus. 50¢.

1951 Annual Report of the John and Mary R. Markle Foundation. 83 pp. 14 Wall St., New York 5, 1952.

Microbial Growth and its Inhibition. First International Symposium on Chemical Microbiology. Geneva: WHO, 1952; New York: Columbia Univ. Press, 1952. 285 pp. Illus. $3.00. English and French text.

Third Annual Report of the Midwest Inter-Library Corporation and the Midwest Inter-Library Center. From July 1, 1951, to June 30, 1952. Chicago: Midwest Inter-Library Center, 1952. 23 pp. Illus.

National Association for Mental Health, Inc. Annual Report, 1951–52. 21 pp. 1790 Broadway, New York 19.

Das Phasenkontrastverfahren in der Medizin. Hans-Georg Hansen, Alexander Rominger, and Kurt Michel. Göttingen: Vandenhoeck & Ruprecht, 1952. 92 pp. Illus.

Population on the Loose. Elmer Pendell. New York: Funk, 1951. 398 pp. $3.75.

Television in Education. A summary report, preprinted from the complete proceedings of the Educational Television Programs Institute held at Pennsylvania State College April 20–24, 1952. Washington, D. C.: Am. Council on Education. ix + 35 pp. Free.

Vitamins in Current Clinical Practice. New York: Lederle Laboratories Div., American Cyanamid Company, 1952. 59 pp.

Mr. Wizard's Science Secrets. Don Herbert. Chicago: Popular Mechanics Press, 1952. 264 pp. Illus. $3.00.

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1952. 4⅞ x 7. 224 pages, 20 illus., 47 tables. $3.50

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MOLECULAR THEORY OF FLUIDS

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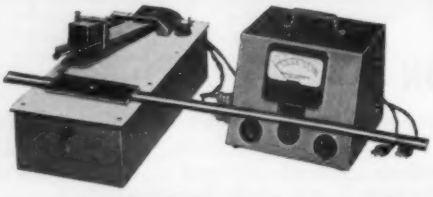

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Jan. 9–10. American Group Psychotherapy Association (Annual). Henry Hudson Hotel, New York.

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Jan. 14–16. Conference on High-Frequency Measurements, sponsored by American Institute of Electrical Engineers, Institute of Radio Engineers, and the National Bureau of Standards. NBS, Washington, D. C.

Jan. 17. Symposium on Blood (Annual). Wayne University College of Medicine, Detroit.

Jan. 19–23. American Institute of Electrical Engineers (Winter General). Hotel Statler, New York.

Jan. 20–31. Inter-American Congress of Philosophy. Havana.

Jan. 22–24. American Physical Society (Annual). Harvard University, Cambridge, Mass.

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Jan. 26–29. American Society of Heating and Ventilating Engineers (Annual). Conrad Hilton Hotel, Chicago.

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Jan. 30. Public Health Workshop, First District Dental Society of the State of New York. Hotel Statler, New York.

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Feb. 2–4. Symposium in Fundamental Biology. Michigan State College, East Lansing.

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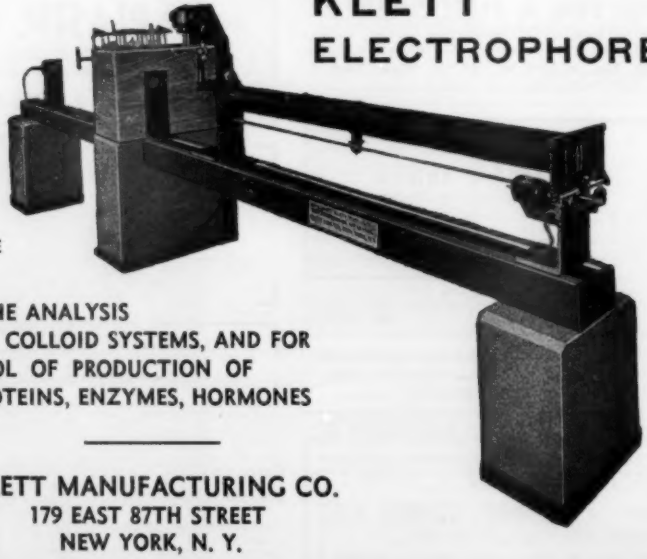

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What GENERAL ELECTRIC People Are Saying

W. R. G. BAKER
Electronics Division

Weapons of Truth: The web of lies and deceit woven by the Kremlin is so tangled and so tenuous that the Communists must erect an iron curtain and must struggle continually to keep the truth from the peoples they dominate. They know they dare not admit the truth about the United States, about our standards of living, about our automobiles and homes and refrigerators, and particularly about our freedoms. They fear the truths carried by the powerful transmitters of the Voice of America, many built by and several operated by General Electric.

Lies and propaganda cannot live long where truth can be heard and seen. The sensitive ear and unblinking eye of radio and television are quick to detect the false note in the voice, or the sudden look of cupidity.

Radio has long listened and reported on governmental affairs, and it has become a past master at interpreting the world's events, although on occasion with too little reporting and too much interpreting. It is time that radio and television came of age, and lent their eyes and ears freely to the cause of communication of truth. Certainly the right of privacy is invaded if we turn on microphones and cameras during an inquisitorial congressional investigation in which no rebuttal is allowed, but this invasion of privacy stems not from the use of radio or television, but from the very procedures used by government.

Let us not forget that our government is a government by the people as well as for the people, and the closer we can come to an informed, enlightened democracy the stronger we will be against the forces of international gangsterism, or against predatory tactics by any group, clique or faction within our borders.

Radio Station WGY
Schenectady, New York

M. C. LEVERETT
Aircraft Nuclear Propulsion Project

Aircraft Nuclear Propulsion: One pound of uranium-235 will liberate heat, on undergoing fission, equivalent to the energy liberated by burning 1,700,000 pounds of gasoline. It is at once evident, if a means can be found for converting the energy of nuclear fission into thrust, that aircraft can fly for very long times on very small amounts of fuel. Indeed, fuel consumption would be measured not in thousands of pounds per hour, but in pounds per day.

In many respects the propulsion of aircraft is an ideal use for nuclear energy. Here, to a higher extent than in any other application, the advantages of a highly concentrated source of heat can be used to good result. Although the goal of producing a nuclear-powered aircraft is an admittedly ambitious one, it is only such high-performance, premium uses of energy which can today justify the consumption of as rare a resource as uranium-235 or plutonium-239. Moreover, it is inescapable that a development of this type has great military significance.

In recent months the government has announced that the nuclear aircraft program is entering a new phase. In this new phase, the Aircraft Gas Turbine Department of the General Electric Company has been given the responsibility for the propulsion system, and the Consolidated Vultee Aircraft Corporation is to supply an airframe.

My belief is that our efforts to fly an aircraft on nuclear power will be successful. The difficulty of the task and the value of the result combine to form a challenge which is, in my opinion, unmatched.

Chicago Section
Institute of the Aeronautical Sciences

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